THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 4 JULY, 1954 NUMBER 4

Shortage Dentistry

Official Publication of

THE ACADEMY OF DENTURE PROSTHETICS

THE AMERICAN DENTURE SOCIETY

THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY

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THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 4 July, 1954 No. 4

THROUGH THE EYES OF THE EDITOR

The members of the Central Nebraska Study Club describe the procedures for making complete dentures which they have shown in their group clinics. The technique is their interpretation of the technique taught by Dr. Fred S. Meyer. The procedure can develop a smooth-running occlusion if it is properly carried out. Extreme care is necessary, however, in order to make sure that the dentures occlude properly in centric jaw relation. The method of recording this relationship may be open to some question. The lateral and protrusive movements that are necessary to develop the "generated path" will cause the bases to displace soft tissue, and may cause an incorrect registration of the movement of the bone of the mandible to the bone of the maxilla (as it is reflected in the generated path). The procedure is clearly described, and the description should be easy to follow.

G. Van Huysen, William Fly, and L. Leonard have made clinical and histologic studies of pathologic mucous membranes of several patients wearing artifical dentures. They found several types of lesions and classified them in such a way as to serve as a guide for the postinsertion care of denture patients. This type of investigation has been needed for a long time. Too often the first treatment of a patient wearing dentures consists of scraping away some part of the denture. This procedure may or may not effect a cure, according to its relation to the real cause of the soreness. The authors suggest that inflammation be eliminated before new dentures are made or before the old dentures are relined. Dentures will fit better on healthy tissue, so why perpetuate a deformity. The incidence of clinically recognized pathosis under dentures reported (about 50 per cent of the 83 studied) emphasizes the importance of this study. It is important to note that it is not the material that the denture is made of but the way it is adjusted for function that is important. So-called "suction chambers" should not be used. Instead, dentures should be made so "relief" is provided to equalize pressures and thus make healthy function possible.

Robert Rapp discusses the occlusion and occlusal patterns of artificial posterior teeth in one of the two prize-winning essays submitted in the American Denture Society Essay Contest for senior dental students. He compares the merits of various posterior tooth forms being used on artificial dentures, and gives a review of current thinking regarding them. His analysis is on various bases, such as, the form of the occlusal surface in nature and the special requirements of artificial posterior teeth. He discusses many factors regarding the selection of posterior teeth and their arrangement. He concludes that the choice is not between anatomic or nonanatomic teeth but that it is between the nonanatomic teeth. Some of the arguments seem valid while others may be open to question.

Elmar A. Siegel discusses the problems of making dentures for patients with advanced Paget's disease. The disease produces changes in the bones of the face which the prosthodontist must consider in making restorations. The case report contains some notations of things to be avoided which are important in caring for these patients.

L. S. Beckett attacks the perplexing prob-

lem of the proper relationship of the hard structures (the teeth) to the soft structures (the mucosa and submucosal tissues) in impressions, as well as in the recording of jaw relations, for partial denture construction. He suggests an excellent classification of occlusal relations in partial denture situations. An interocclusal record is prescribed for each. The one suggested for Type A might be open to question because it is unlikely that the occlusion of the remaining teeth is in harmony with centric jaw relation in most mouths. The observation that the interocclusal records should be made with pressures that are comparable to those used in the impression procedure seems sound. The use of small wire occlusal rests on the occlusion rims wherever possible is an excellent suggestion, as is the use of lined occlusion rims.

Victor L. Steffel discusses the various methods of relining lower partial dentures. He points out the fact that, in some ways, this operation is more simple than relining complete dentures, and states the objectives of relining. His classification of partial dentures which need relining will help to determine the relining procedures which will serve best in each instance. His descriptions of the various satisfactory methods available should prove helpful once the choice of the best method for the situation has been made. The suggestions are based on sound biologic principles.

Mortimer C. Davis and George Klein discuss the indications for combination gold and acrylic restorations, and describe the techniques for making several kinds of these restorations. They believe that these veneer restorations have many advantages over combinations of gold and porcelain. The methods of construction suggested are practical and should provide a guide to those who use these materials.

Joseph E. Ewing calls attention to the dangers of over-specialization in dentistry. He believes that every young dentist should be trained adequately in all phases of dentistry in order that he can render a coordinated service to his patients. He illustrates his premise by presenting a case history in which many phases of dental service are rendered to the patient. The treatment was quite complicated at certain points, but it was not beyond the capabilities of an adequately trained general practitioner. There are some dangers in his suggestion, however. It is *necessary* that the dentist (regardless of his type of practice) be adequately trained and experienced to do this type of work. The thought occurs that the prosthodontist needs this versatility more than any other specialist because his are the problems resulting from all of the other phases of treatment. He should be well grounded in general dentistry before he becomes a specialist. The treatment of this patient was quite ingenious when it is considered in its entirety, but the various stages of treatment were relatively simple. The success of the treatment depended upon good judgment based upon a wide experience.

R. C. Brumfield analyzes the load-carrying capacities of posterior fixed bridges on the basis of mechanical principles. The results of this investigation should serve as a guide to better bridge design. The charts provide a means for determining the actual requirements for strength of each part of the bridge, including the solder joints. While the technical analysis may seem complicated, the use of the data is not too difficult to be practical.

Carl P. Regli and Herbert L. Gaskill report on further studies of the deformation of denture bases which occurs during function. In this work, they compare the deformation of different kinds of denture bases on both high and flat ridges. They found and measured three kinds of deformation which could affect the success of dentures. As would be expected, the metal dentures were less subject to change from external forces than were the plastic bases. While this deformation of denture bases must have a bearing on comfort in the wearing of complete dentures, its effect probably would be magnified in partial dentures to a point of serious consideration. This work indicates the need for very rigid major connectors (lingual bars) on distal extension partial dentures.

K. Asgarzadeh and F. A. Peyton report their investigation of the physical and working properties of seven zinc oxide-eugenol impression pastes. They noted considerable

variations which may be of great practical importance. They suggest that specifications should be established for this class of dental materials. They have not pointed to the relative merits or deficiencies of the materials studied because no standards have been set. The tests they have used seem to be good and might serve as a basis for establishing specifications. Further studies of the materials should be made to determine which are the desirable qualities. Undoubtedly, other tests must be devised in order to determine the relative merits of these materials, while some of the tests used may not be necessary. Probably, most dentists choose the material according to its working qualities, but that may not be the most important consideration.

Ernest Baden discusses the fundamental requirements for the successful construction of obturators and speech aids, and the function of these appliances. This type of appliance is logically divided into the hard palate section, the velar section, and the pharyngeal section. The principles he has established for each section should serve as guides to prosthodontists in cleft palate rehabilitation. The importance of cooperation between the various health specialists in the treatment of cleft palate patients is stressed as it should be. Too often the prosthodontist must work with what is left after other specialists have failed in their efforts at rehabilitation. A coordinated effort will promise the best results.

—Carl O. Boucher

CONSTRUCTION OF FULL DENTURES WITH BALANCED FUNCTIONAL OCCLUSION

As Taught by Fred S. Meyer, D.D.S.

*The Central Nebraska Study Club**

Lexington, Neb.

1. Make accurate stone casts from good impressions. Score the bases of the casts, and adapt rigid baseplates to these casts.

2. Construct hard wax occlusion rims on the baseplates. These occlusion rims should be about one-half inch wide on the occlusal surfaces.

3. Determine vertical dimension: Place the lower occlusion rim in the mouth. Trim the anterior part of the lower occlusion rim to the desired height of the lower anterior teeth, and the posterior part of the occlusion rim to two-thirds of the height of the retromolar pad. This establishes the occlusal height of the lower teeth. The trimming of the upper wax occlusion rim is determined by esthetics and the free-way space. The upper occlusion rim should occlude approximately with the lower occlusion rim. Approximate balance of the hard wax occlusion rims is obtained by having the patient make lateral and protrusive jaw movements as wax is added to one rim, and removed from the other, until an approximate curve is made. When the occlusion rims maintain a good contact in all these movements, the approximate occlusal plane will have been established. Mark the median line on the occlusion rims, and with a pair of locked dividers make indentations in the median line so the vertical dimension can be checked later.

4. Generate the primary occlusal path in soft wax:

A. Shorten the vertical dimension of each hard wax occlusion rim 2 mm., being careful to maintain the approximate curve. This is done by making indentations about one-quarter inch apart with a hot 2 mm. chisel (Fig. 1), and trimming the wax to the depth of the indentations. Add 3 mm. of soft counter wax to each occlusion rim and cover the occlusal surfaces of the counter wax with 0.001 tin foil (Fig. 2). Lubricate the tinfoiled surfaces with petroleum jelly.

B. Return the occlusion rims to the mouth. By lateral and protrusive jaw movements and slight pressure, the primary path is generated (Fig. 3) until the vertical dimension is re-established (as determined by the locked dividers).

5. Establish the approximate centric relation:

A. Remove the lower occlusion rim from the mouth, and trim enough wax from the labial surface so that the upper rim will protrude over the lower, and re-mark the median line on the lower, and return it to the mouth.

Resumé of a clinic presented at the meeting of the American Denture Society, Chicago, Feb. 8, 1953.

Received for publication Jan. 13, 1954.

*Members of Central Nebraska Study Club: Von Arnold, D.D.S., L. R. Beattie, D.D.S., J. G. Colgan, D.D.S., F. T. Daly, D.D.S., Ray Langfeldt, D.D.S., G. V. Reynolds, D.D.S., A. T. Ridder, D.D.S., L. E. Sayles, D.D.S., A. R. Transue, D.D.S.

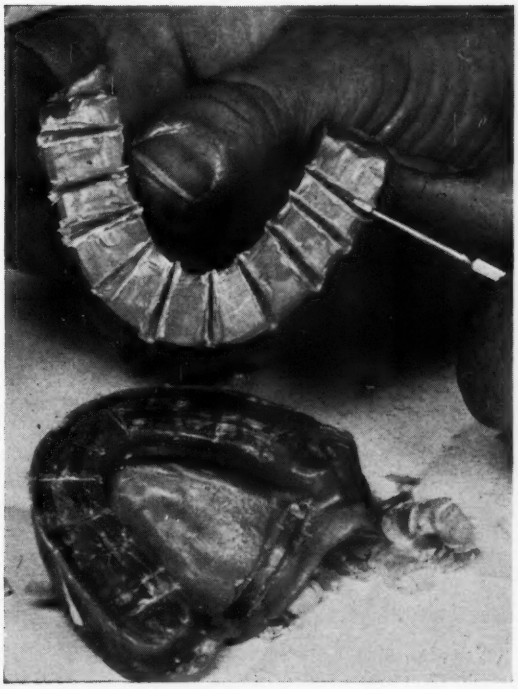

Fig. 1.—Removing 2 mm. from hard wax occlusion rims.

Fig. 2.

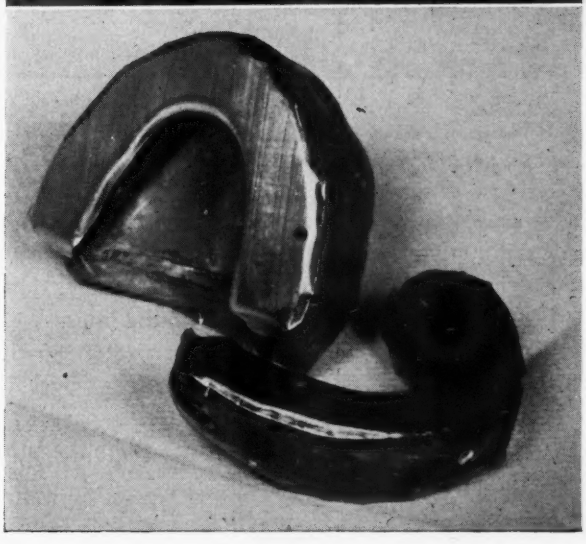

Fig. 3.

Fig. 2.—Hard wax occlusion rims with soft counter wax and tin foil added.
Fig. 3.—Generated primary paths.

B. Have the patient close in the most retruded position. With a pointed instrument, make an indentation in the upper occlusion rim just above the median line marked on the lower rim. Have the patient make various jaw movements, and if he comes to rest at this point each time, this is his approximate centric relation. The wax rims are stapled together, and a face-bow transfer is made to an articulator that permits no lateral movements.

6. A reproduction of the primary wax path is made in stone:

A. A baseplate is adapted to cover the entire upper surface of the lower cast, excluding undercuts. The upper wax primary path is boxed-in in the palate, and closed into a mixture of stone poured on the new lower baseplate to the established vertical dimension.

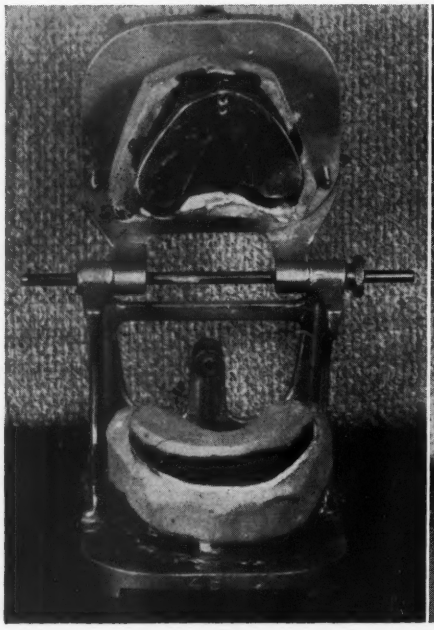

Fig. 4.

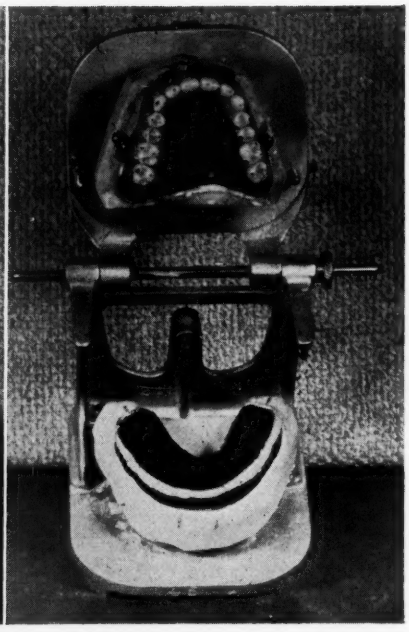

Fig. 5.

Fig. 4.—Reproduction of primary wax path in stone.
Fig. 5.—Upper teeth set to the primary stone path.

B. When the stone is set (Fig. 4), separate it from the generated wax path by opening the articulator, trim, and mark lines on the stone primary path above the crest of the posterior ridges. The lines serve as guides for setting up the posterior teeth. It is not necessary to set the teeth on the lines.

C. To locate crest of ridge lines on the primary stone path: Remove the primary stone path from the cast. Place a straight edge over the crest of the posterior ridge. Mark the distal end and the anterior part of the cast under the straight edge. Replace the stone primary path, align the straight edge with the marks, and draw the lines on the stone path.

7. Set the upper anterior teeth for esthetics. Small portions of the anterior part of the primary stone path may be removed in order to set the anterior teeth

as desired. All major cusps of the posterior teeth must touch the primary stone path (Fig. 5). Grind cusps if necessary. Posterior teeth should be set so the medial grooves and pits are in a straight line.

8. Set the lower teeth to the upper teeth, and try the wax dentures in the mouth for esthetics.

9. Process the upper denture.

10. Remount the upper denture on the articulator before removing it from the cast, and correct it to the stone primary path. Paint the stone path with Prussian blue, and spot grind the teeth until all major cusps touch the stone path.

11. Preparation for cusp and sulci analysis:

A. Mount a black modeling compound rim on another lower baseplate.

B. Soften the occlusal surface of the compound, and close the upper teeth into the compound to the vertical dimension recorded by the articulator.

Fig. 6.—Preparation for cusp and sulci analysis.

C. Trim away the *occlusal* surface of the compound, except the impressions of the pits, sulci, and marginal ridges, and leave a table on each side of these impressions to carry a soft cuspal wax later (Fig. 6). Mark the median line in the compound.

12. Remove the upper denture from the cast, trim and polish it, and place it in the mouth.

13. Cusp and sulci analysis: Soften the modeling compound ridges slightly, and have the patient close into centric relation with the median line marking as a guide. The ridge on one side will probably register more than the other side. A slight amount of compound should be added to the side with the lesser registration, and while the compound is still soft, have the patient close into centric relation a second time. If all of the cusp and sulci registrations are sharply defined, the pressure is even on both sides. Remove the compound rim from the mouth and trim the excess compound as before. Replace the rim in the mouth. The patient is asked to slide the jaw to the lateral positions. All buccal cusps on the working side, and all lingual cusps on the balancing side should touch the ridges in the compound simultaneously. If a cusp does not touch, deepen the sulcus or groove

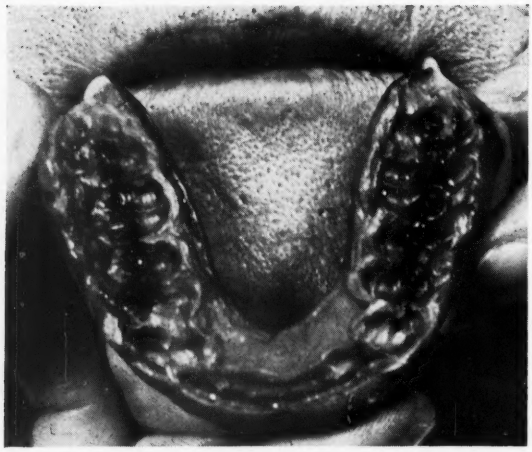

Fig. 7.—Wax cuspal path.

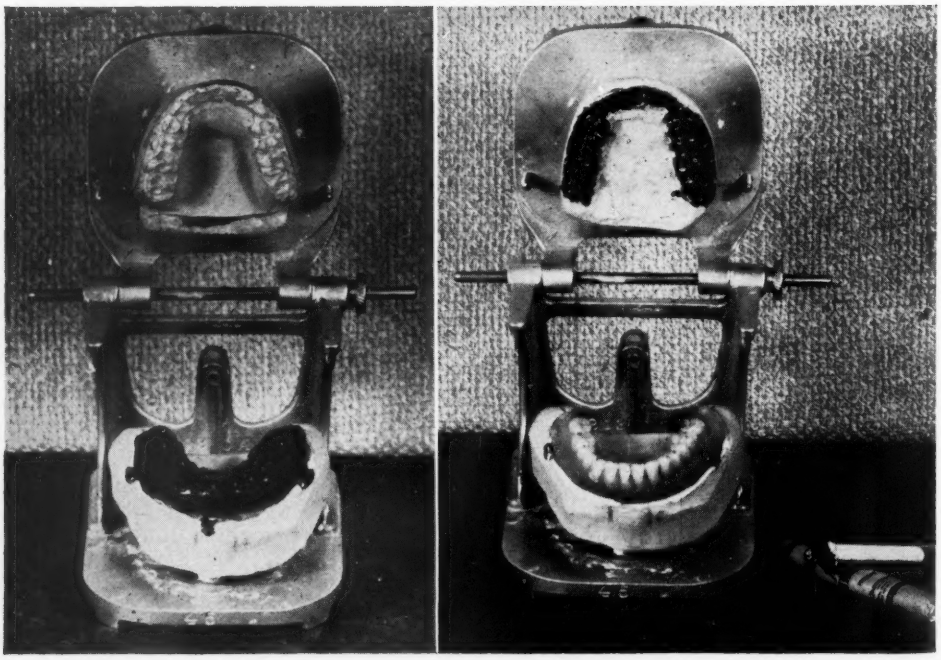

Fig. 8. Fig. 9.

Fig. 8.—Reproduction of the wax cuspal path in stone.

Fig. 9.—Correcting the lower processed denture to stone cuspal path.

or marginal ridge of that tooth, add a bit of compound to the ridge, and have the patient close into centric relation, thus the ridge is heightened at this point. This step is repeated, if necessary, until all cusps touch. When this is accomplished, the cusp and sulci analysis will be complete.

14. Generate the cuspal path: Add cuspal tracing wax to the compound tables (on both sides of the compound ridges) to a height a little above the compound ridges. Also add cuspal wax to the anterior portion of the compound rim. Place the compound rim in the mouth, and have the patient close in centric relation, then make lateral and protrusive movements from centric position to the height of the compound ridges. The compound ridges must show plainly and evenly through the cuspal wax, and there should be a smooth, even tracing of the cusps in the wax (Fig. 7). It should be emphasized that after a movement is made from centric position, the patient should open his mouth and close again in centric position before the next movement is made. The wax will tear if movements are made both ways.

15. Make a counterpart of the cuspal wax path in stone: Return the cuspal wax path to the lower cast on the articulator. Pour the cuspal path in stone, and attach it to the upper arm of the articulator. Separate the cuspal wax path from the stone cuspal path by opening the articulator, and trim away the excess stone (Fig. 8).

16. Reset the lower teeth to the stone cuspal path. Process the lower denture. Return the processed lower denture to the articulator before removing it from the cast. Paint the stone cuspal path with Prussian blue, and correct the lower denture by spot grinding the teeth to fit the stone cuspal path (Fig. 9). Remove the lower denture from the cast and trim and polish it.

CONCLUSION

We of the Central Nebraska Study Club have used this technique for the past ten years. It has been highly successful in our hands. We believe that any one can use it with equal success. It requires no special skills. It will work in any man's hands. It was quite an effort for our group of nine men to forget most of our old ideas and start anew. We wish to suggest that, if you adopt this technique, you form study club groups of six, eight, or ten men to explore its possibilities. We predict that your efforts will be well rewarded.

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LEXINGTON, NEB.

ARTIFICIAL DENTURES AND THE ORAL MUCOSA

G. Van Huysen, D.D.S., Lieutenant Colonel William Fly, Dental Corps, United States Army, and Major L. Leonard, Dental Corps, United States Air Force

Departments of Oral Histopathology and Prosthetic Dentistry, Indiana University School of Dentistry, Indianapolis, Ind.

ONE of the functions of the tissues covering the body and those extensions of this integumentary system lining the body cavities is that of protection from mechanical and other stresses. That oral mucous membranes can endure mechanical stress is demonstrated not only by their resistance to the physical properties of masticated foods, but also by the fact that foreign bodies such as artificial dentures can function satisfactorily in most mouths. The toleration of most oral mucous membranes to well-constructed denture bases has been proved by considerable clinical experience over the years, but it is also clinically obvious that some dentures are associated with pathologic tissue reactions. It should be of interest to the dental profession to understand the nature of these changes and the factors which control them. It should be of interest to know whether tissue pathosis under dentures is caused by the denture itself or the nature of the individual's tissue or both.

Since the majority of denture-wearing patients are free of signs and symptoms of pathologic change, the possibility that some persons' tissues react in an unusual manner is of course of primary importance. The limitations as well as the usefulness of any therapeutic measure should, if possible, be determined. Dentistry realized long ago that although technical proficiency is important, biologic principles must also be observed. Dentistry has also learned that one cannot guarantee the success of any appliance or therapeutic treatment, because living tissues differ in different individuals and are not static but may and do change over a period of time.

Many times in the past, case reports and textbook illustrations have cited instances of mucous membrane lesions associated with artificial dentures. However, there has been only one serious attempt[1] to classify conditions and make a systematic study of the findings basic to these difficulties. It is the purpose of this study to examine clinically and histologically pathologic mucous membranes of patients wearing artificial dentures. Since more than one type of lesion will be described, an attempt will be made to classify as well as study the nature of the lesions.

The opinions or assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the United States Army or Air Force Dental Corps.

Received for publication Nov. 25, 1953.

DENTURE LESIONS

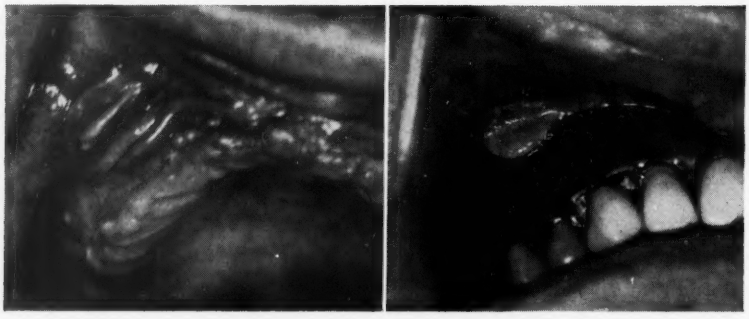
New dentures, before they have become completely adjusted, may cause tissue trauma. New dentures or old dentures may on occasion slip out of place during function and also traumatize tissue. These acute short-lived injuries are obvious both from the standpoint of cause and treatment, and will not be considered at this time. This study will consider the changes which are of a chronic nature that take place in the edentulous mucosa, approximating vulcanite and acrylic denture bases. The lesions can be tentatively arranged as three general types. The first type consists of tissue inflammation and hyperplasia appearing along the borders of old dentures. A second type of lesion appears as inflammatory hyperplasias in the palatal area and other areas such as alveolar ridges where the mucous membrane is tightly adherent to the bone. A third type, a nodular hyperplasia, with or without evidence of inflammation, occurs most commonly in the central palatal area. The first type, it is obvious, is due to trauma. The second type, also inflammatory, could also be due to trauma. All that one can say about the third type of lesion is that it has been, in the past, associated with prosthetic appliances.

TYPE I LESIONS

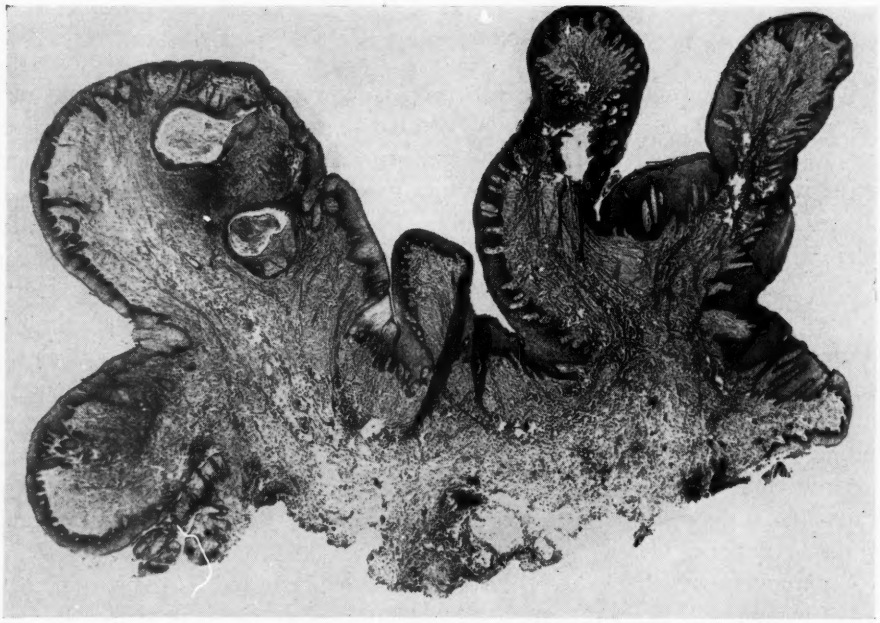
A lesion of the first type, that is, hyperplastic mucosa along the borders of ill-fitting dentures, has been very often illustrated in textbooks of dental prosthesis, surgery, and pathology. This lesion has been called[2] redundant tissue, gingival hyperplasia, areolar hyperplasia and epulis fissuratum. One of these lesions is illustrated in the first case in this study. Fig. 1, *A* and *B* shows a maxillary denture with a lobe of hyperplastic tissue folding over the margin of the denture flange, and the mucobuccal fold without the denture, where a characteristic multilobed mass of tissue can clearly be seen. This lesion has been described numerous times in the literature and in textbooks. It is a simple matter to remove these lesions and prepare new dentures. If the hyperplasia is not too bulky, relieving the trauma by adjustments to the old denture or the construction of a new, properly fitting denture may reduce the lesions without resorting to surgery. It is obvious that the inflammation, and new growth of epithelium and connective tissue is due to trauma from the denture margin that has become overextended because of underlying tissue changes.

A photomicrograph of the lesion is also seen illustrated in the lower part of Fig. 1, *C*. The epithelium covering the lobulated lesion varies in thickness, and is covered with a thin layer of parakeratin. There is a moderate thickening of the spinous layer with a normal arrangement of the other layers. The underlying connective tissue is composed of some dense and some loosely interlacing bundles of collagenous fibers, showing a moderate number of fibroblasts and fibrocytes. There are occasional collections of chronic inflammatory cells, chiefly lymphocytes and plasma cells in scattered areas, particularly in the subepithelial papillary layer. There are several small epithelium-lined sacs lying within the altered lamina propria. These sacs appear to be filled with keratin and desquamated epithelium. The epithelium of these cystlike structures is, however, continuous with the surface epithelium. This was clearly demonstrable when serial sections of the tissue were cut

and viewed in sequence. These saclike areas were surrounded by an intense chronic type of cellular exudate and in all probability were produced by excessive growth of the connective tissue producing an inversion of the epithelium.



A. *B.*



C.

Fig. 1.—*A* and *B*, Tissue hyperplasia described in Case 1. *C*, A photomicrograph of the histologic section from the biopsy

Clinically these lesions are very similar one with another. They vary some in size, color, and number of lobes, depending upon the proportions of inflammation and the connective tissue built up by the irritation. Some are highly vascular and others are more fibrosed, depending upon the amount, chronicity, and degree of trauma. Since this type of lesion has been frequently described, only this one case will be demonstrated here.

The other types of lesions reviewed in this study are found on adherent denture-bearing mucosa most conspicuous in the palate. The lesions are inflammatory and nodular in type, but unlike the hyperplasias mentioned previously, their cause and treatment is not quite so obvious.

In 1936 Pryor[8] described a lesion of the edentulous mucosa which he called "chronic denture palatitis." Earlier, Black[4] and Kirk[5] both referred to inflammatory lesions of the palate. They attributed these inflammatory lesions of the denture-bearing palatal mucosa to contact with old and unhygienic dentures. Hildebrand[6] considered prosthetic appliances as foreign bodies, and reviewed the literature concerning their association with mucous membrane lesions. In his review, inflammatory changes of the palate under dentures were variously attributed to red rubber vulcanite, that is, the chemicals in it, metal bases, bacteria associated with unclean dentures, and pressure from rubber suction disks. Cahn[7] referred to palatitis under dentures as "denture sore mouth." He described the condition as subepithelial inflammation and attributed the changes to infection of the mucosa with *candida albicans.* He ruled out allergic sensitivity, and claimed that the lesions occurred in instances where the dentures fitted correctly. He was of the opinion that "denture sore mouth" was most severe in debilitated subjects. Cahn used antiseptics on both plates and tissues for treatment of the condition.

Daley, Healy, and Sweet[9] described a similar type of palatitis as follows: "The mucosa is deep red in color, corrugated, and fissured in appearance, a varying degree of hyperplasia is evident and the inflamed area rarely extends beyond the periphery of the dentures." These authors believed that many such lesions were due to "ammoniacal burns." They found no patients that were skin sensitive to vulcanite of any type, and according to them there was no evidence of injury from pressure of the denture.

Hecht[9] described five cases of chronic denture irritation. He included one case of palatitis of the nodular type which he associated with pressure from a relief chamber. The lesion, according to Hecht, covered an area both inside and outside of the relief chamber outline and, "it showed innumerable, concentric coalesced papillomas, mulberrylike in appearance." He attributed the lesions to "irritation from ill fitting dentures and debris."

Pendleton[10] described changes in denture supporting oral mucosa. These changes consisted mainly of epithelial keratinization due to mechanical stimulation. He did recognize histologic evidence of bone absorption and inflammation, but did not attempt to correlate the latter with clinical lesions.

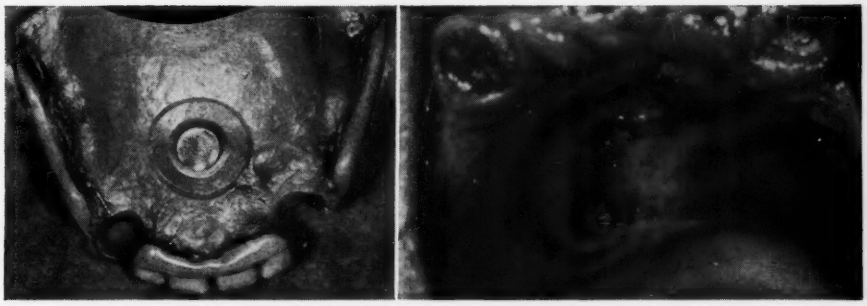
Recently Fisher and Rashid[11] described a more severe type of lesion of the palate which they called papillary hyperplasia. They associated the condition with the wearing of an unhygienic artificial denture. Their histologic sections of the lesion showed inflammation, and they believed that chronic, excessive retention of food debris, and stagnant oral secretions caused the lesion. It was their opinion that the appropriate therapy was the discontinuance of the use of the unsatisfactory denture. The authors cautioned the reader against considering these lesions as tumors. They were emphatic in their opinion that the lesions were inflammatory and in no sense of the word could they be considered neoplastic.

In the same journal, Thoma and consultants[12] described a very unusual case which they called "papillomatosis" of the palate of a man who had worn the same denture for 26 years. Although the lesion appeared to be clinically malignant, it was considered histologically a benign hyperplasia of epithelium and connective tissue by several consultants. It was not possible to determine the cause of the lesion, and surgical removal was the treatment of choice.

The subject of denture sore mouth has been carefully studied by Nyquist, who has reported his observations in a very interesting monograph.[1] He arranged his cases of palatitis or what he called "denture sore mouth" into three classes as follows: (1) diffuse fairly smooth, hyperemic, edematous mucosa under entire denture; (2) discrete, inflamed sometimes granular mucosa with certain predilection sites particularly under vacuum chambers and suction disks; and (3) a combination of 1 and 2. He was of the opinion that these lesions were caused by traumatic, allergic, and toxic stimulae. Nyquist did not include in his discussion those hyperplastic mucosal lesions occurring about the borders of old dentures and described briefly in the first case of this review.

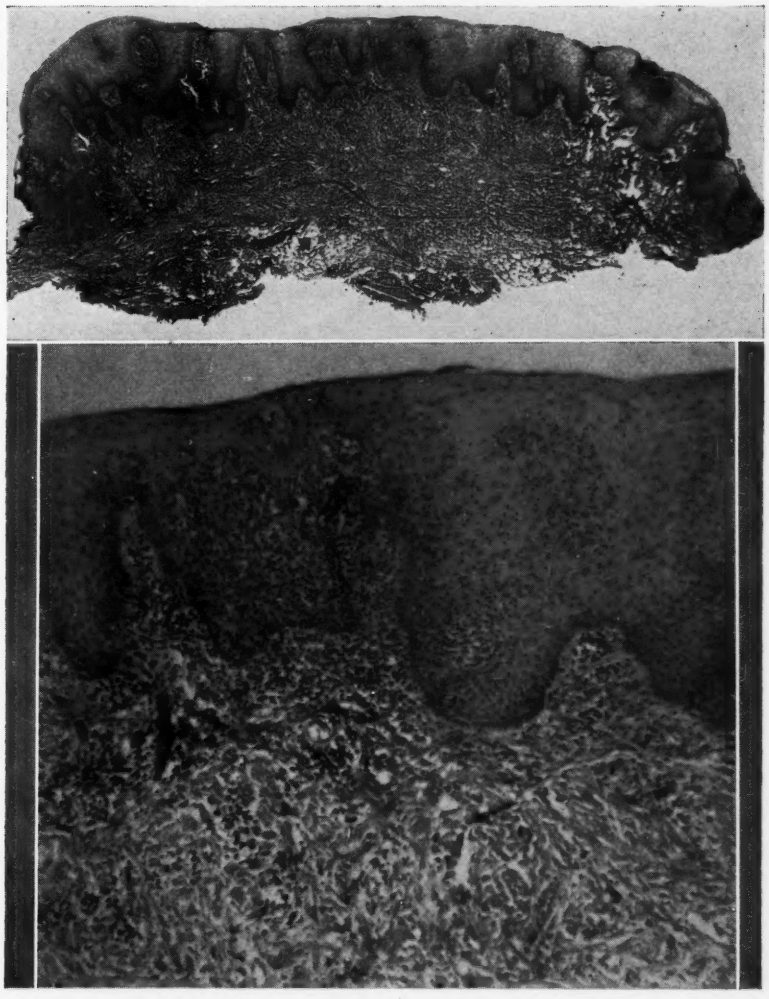
The second case of this report is that of a 50-year-old woman who came to the clinic wearing an old denture. Fig. 2, *A* and *B* shows the palate and corresponding surface of the denture that had been put into her mouth years ago. When the patient was first seen, there were numerous diffuse small and large reddened, slightly granular, areas of mucous membrane beneath the denture. One can also see in the palate, a raised circular area of tissue with a depressed center. This impression was made by the metallic button in the palate of the denture (Fig. 2, *A*). This button originally carried a rubber suction cup attached to it. A biopsy was made through this raised palatal tissue that fitted into the depression around the metallic button fixed to the denture.

Fig. 2, *C* and *D*, shows two magnifications of the histologic section that was made from the biopsy. The epithelium varies considerably in thickness, showing some coalescence and elongation of the rete pegs. A moderate number of leukocytes are seen in the epithelium. Aside from this, however, there is exhibited the usual architecture and the usual distribution of the layers of the epithelium. The cells of the basal layer are intact in all areas. The underlying connective tissue is composed of thin, interlacing bundles of collagenous fibers showing a moderate number of interspersed fibroblasts and fibrocytes, as well as a diffuse sprinkling of chronic inflammatory cells. These are chiefly plasma cells and lymphocytes. This inflammatory cell exudate is most marked in the papillary layer where the collections of cells become quite dense and are seen to be infiltrating the epithelial layer to a minor degree. Although a moderate number of thin-walled blood vessels are seen scattered diffusely throughout the connective tissue, there is no marked hyperemia histologically. The lamina propria proper is thickened by the increase in dense connective tissue. This histologic section shows the tissue hyperplasia that had been built up (Fig. 2) to fit into the depression surrounding the metallic button on the denture.



A. *B.*

C.



D.

Fig. 2.—*A* and *B*, The palatal surface of the denture and the palatal mucosa of Case 2. *C* and *D*, Two magnifications of the histologic section from the biopsy which was taken through one side of the raised area.

This patient had the two remaining carious teeth removed and new dentures made. An examination of her mouth eight months later showed no pathosis.

A third case is similar to the second one. The full maxillary denture carried on its mucosal surface the remnants of a suction cup device like that shown in Fig. 2. The palatal imprint of this device is shown in Fig. 3. There is no evidence of mucous membrane inflammation, and there were no carious teeth present in this mouth. Bacterial smears of the dentures and palatal mucosa in both cases showed the presence of organisms, but there was no specific difference noted, neither case having yeastlike organisms. The palatal hyperplasia disappeared completely when a new denture was worn for one week.

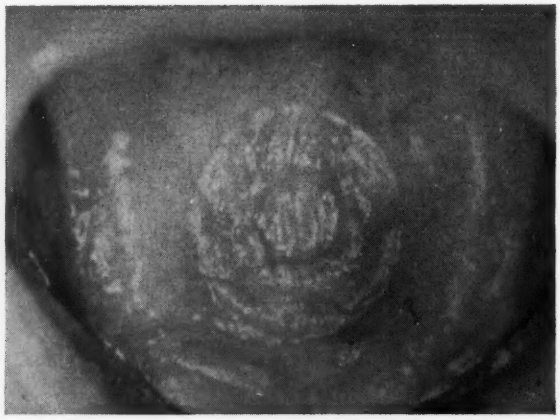


Fig. 3.—Changes in the palatal mucosa under a denture with remnants of suction device.

The fourth case is that of a 55-year-old woman who had worn for 30 years the vulcanite denture shown in Fig. 4, *A*. The palatal mucosa showed a corresponding heart-shaped area in the tissue.[13] Fig. 4, *B* shows also that there were patches of inflamed mucosa in the palate. The area of inflammation of the mucous membrane does not coincide with the outline of the vacuum chamber.

A new denture was made for this patient, and the palatal membrane became almost free of inflammation. The lower part of Fig. 4, *C*, shows two areas of redness, one in the anterior and the other in the posterior of the palate. The mucosal impression of the vacuum chamber had disappeared. It is obvious from this and the other cases described that vacuum chambers or smooth pieces of metal pressing against the mucosa do not necessarily cause inflammation. It is also obvious that raised swollen mucosa that frequently fills denture depressions such as vacuum chamber relief areas, does not necessarily represent a permanent tissue change. It was impossible to determine what caused the residual palatal inflammation. It is also evident that the construction of a new denture may improve tissue health but still may not eliminate all of the pathosis. It can only be assumed that not all of the irritation has been removed by construction of the new dentures.

Vacuum chambers and other suction devices have been shown by Campbell[14] to interfere with the adhesion of maxillary dentures. This study shows that such

devices also may cause undesirable alteration of the mucous membranes. Even though vacuum chambers do not produce permanent changes, nor do they necessarily cause inflammatory changes, they have no real value and therefore should not be used.

In all but the first case so far in this report, it was impossible to demonstrate any direct evidence of trauma because of specific irregularities. All of the dentures had been worn for a long time, and it could be said that they did not fit properly. However, it was not possible to show that they were ill-fitting by any specific test.

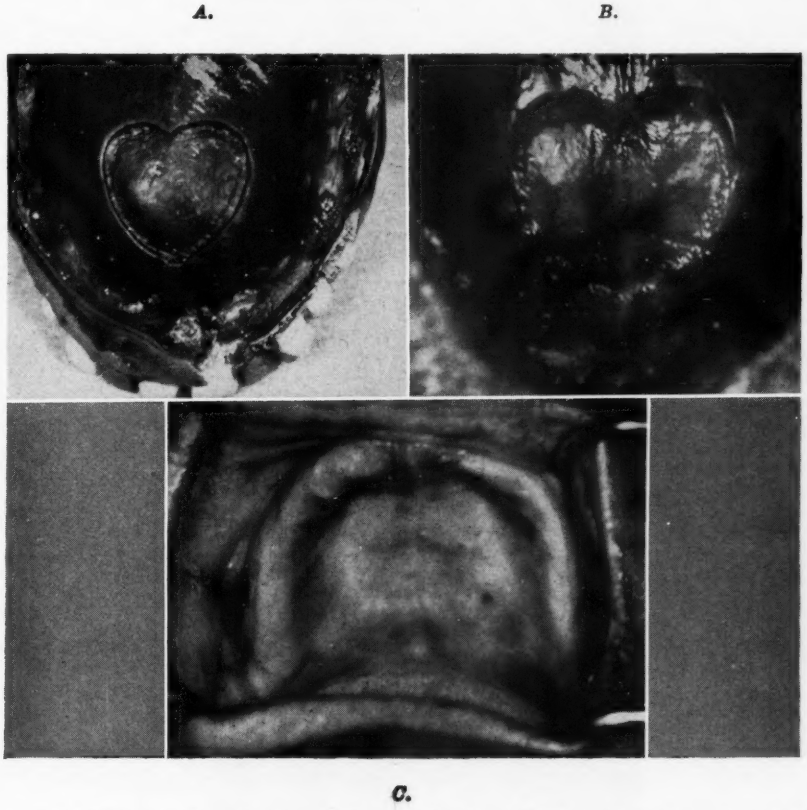


Fig. 4.—*A*, The heart shaped vacuum chamber in the palatal surface of a vulcanite denture. *B*, A picture of the palate covered by the denture. *C*, The palatal mucosa after wearing a denture without a vacuum chamber.

The fifth case shows two reddened areas in the palatal mucosa within the tissue impression of the vacuum chamber (Fig. 5, *A* and *B*). Two very obvious prominences on the impression surface of the acrylic denture correspond to the areas of redness in the palatal mucosa. The 50-year-old patient had been wearing this denture for six years. No biopsy was taken of this obvious area of inflammation. It is believed that this case demonstrates the fact that inflammation of the oral mucosa can be produced by denture trauma, and that most cases of denture sore mouth of this type are due to denture trauma.

The sixth case shows an inflamed palatal mucosa of a 30-year-old woman (Fig. 5, *C*). The inflamed mucosa was seen beneath the palatal bar of a removable partial denture. No biopsy was taken, and a new denture was not made for this individual. The patient was unaware of the redness until it was pointed out to her. In other words, the lesion was painless and the partial denture, as far as the patient

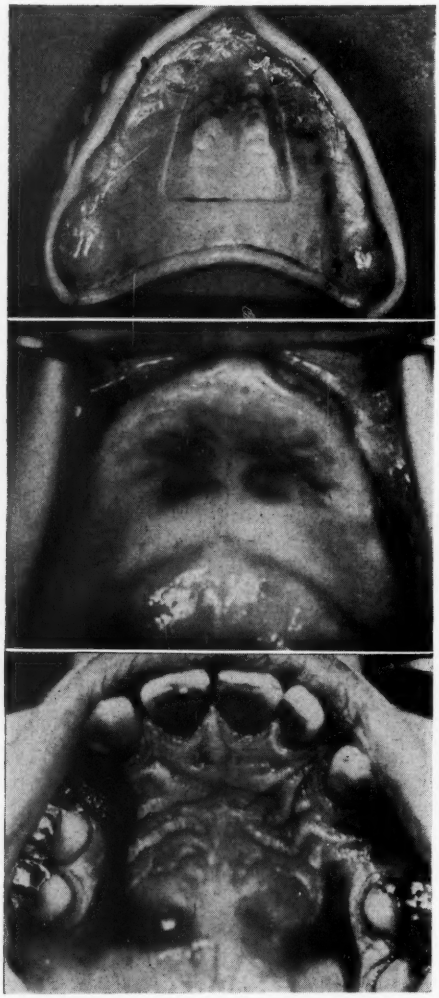


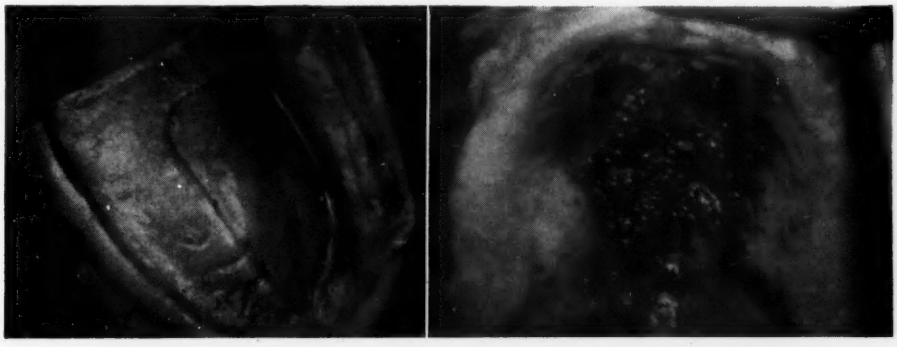
Fig. 5.—*A* and *B*, The palatal surface of the denture shows two prominences within the outline of the vacuum chamber. These correspond to the areas of redness in the palatal mucosa. *C*, Inflamed palatal mucosa which has been in contact with the metallic frame of a partial denture.

was concerned, was entirely satisfactory. The patient would not agree to have a new partial denture made for her. Here again one can see that pressure on the oral mucosa of some mouths will be associated with inflammation.

The seventh case shows another type of lesion of the palatal mucosa (Fig. 6, *A* and *B*.) This 41-year-old woman came in wearing the denture shown. She had

no lower denture and said that she wore the upper only while she was working. The palatal mucosa showed a reddened nodular surface under and slightly beyond the limits of the vacuum chamber relief area. This lesion was composed of small translucent, shiny nodules interspersed with reddened, obviously inflamed mucosa. This redness subsided considerably when the patient stopped wearing the denture. The denture was eight years old, but the patient said that the lesion was noticed about two years after the denture was first made. A biopsy of the lesion was taken, and Fig. 7, *A* and *B* shows photomicrographs of the histologic section.

The histologic section shows elongated epithelial rete pegs, the surface epithelium between the rete pegs being thin and in some areas almost nonexistent. No ulceration of the tissue is seen, and leukocytes are invading the epithelium. There is no keratinization, but the layers of the epithelium are otherwise not abnormal. There are occasional isolated islands of epithelial cells in the corium beyond the basal layer of the epithelium, and the boundary between the basal epithelium and connective tissue is definitely demarcated. There are a few attempts at pearl formation in the epithelium. There are more mitotic figures present than one would normally anticipate, but there is no evidence of malignancy in this histologic section.



A. *B.*

Fig. 6.—*A* and *B*, The reddened nodular palatal mucous membrane extending beyond the limits of the vacuum chamber of the denture.

The papillary connective tissue area shows a marked diffuse invasion of lymphocytes, plasma, polymorphonuclear and mononuclear phagocyte cells. The lamina propria is quite normal, and the mucous glands are normal with no evidence of obstruction or inflammation. One can see that the nodules are made up of epithelial and inflammatory hyperplasia. These are superficial as far as the mucosa is concerned.

The eighth case showed nodular hyperplasia and redness of the palate[13] and is illustrated in Fig. 8, *A* and *B*. This photograph does not show clearly the slight redness that prevailed throughout the tissue covered by the denture base. Fig. 8 also shows the rough denture surface, and the lining of plastic material that was applied by the patient to make his dentures "fit better." The centric occlusion of

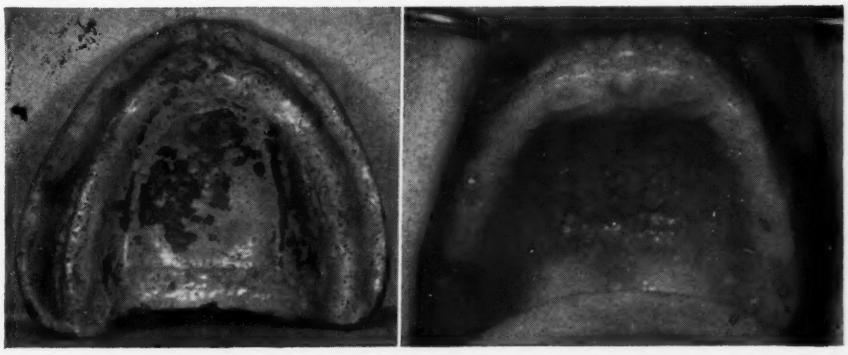
the dentures was good, and the side view of the patient showed that there was some loss of intermaxillary space.

A.

B

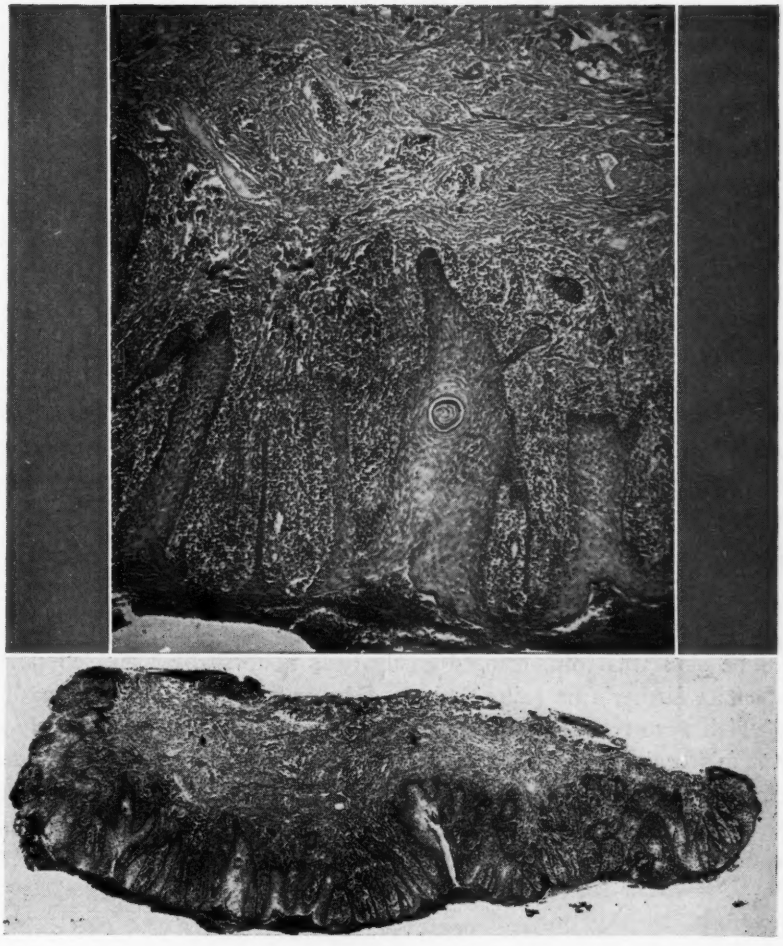
Fig. 7.—*A* and *B*, The photomicrographs of the palatal biopsy.

The histologic sections (Fig. 8, *C* and *D*,) show the following picture. The covering epithelium varies markedly in thickness and exhibits long fingerlike rete pegs extending deeply into the connective tissue in many areas. In one of



A. *B.*

C.



D.

Fig. 8.—*A* and *B*, A denture with a temporary lining inserted by the patient, and the nodular palatal musoca. *C*, Low magnification of the histologic section of the biopsy. *D*, Area of epithelium in greater detail.

the elongated rete pegs at the lower right of Fig. 8, *D* there is a small area of dyskeratosis, somewhat pearl-like in appearance. There is a generalized infiltration of the spinous layer by both polymorphonuclear leukocytes and lymphocytes. One can see both intra- and intercellular edema of the spinous cells. The basal layer of cells appears intact in all areas, and no vagarious cells are noted. The lamina propria is made up of interlacing bundles of fibers interspersed with a moderate number of small blood vessels and fibrocytes. The papillary layer is densely infiltrated with plasma cells and lymphocytes.

As soon as the biopsy wound was healed, new dentures were constructed for the patient, but the mucous membrane did not improve with the new dentures. There was not quite so much redness, but the nodularity of the palatal mucous membrane continued undiminished.

The ninth case in this series was similar to the preceding one. Nodular palatal tissue was discovered beneath the denture. The patient, a man 56 years of age, had been wearing an acrylic denture for ten years. Some but not all of the redness subsided when the patient left his dentures out of his mouth for a few days. The histologic section was similar to that described for the preceding case. Again there was evidence of hyperplasia of the surface epithelium with leukocytic infiltration of the papillary layer. There was some evidence of thickening of the lamina propria, but one could not say that this was abnormal. There was papilloma-like hyperplasia of the tissue.

A new denture was made for this patient. The nodularity and redness of the tissue persisted in spite of the fact that the new denture did not contain a vacuum chamber. This nodularity and inflammation of the oral mucosa of this man's palate continued even though he was placed on a rigid hygienic regime. He was advised to pay particular attention to the cleanliness of his mouth and dentures, to scrub the dentures with soap and water four times a day, and to leave the dentures out of his mouth at night.

This patient showed, in addition to this oral lesion, premature atrophy of the skin. His lips were unusually dry and frequently cracked, and there was a scar on his left cheek from which the patient said a basal cell tumor had been removed. The skin was thin, bruised easily, was abnormally wrinkled, and could be classified as farmer's or sailor's skin. The patient's lips showed scaling and cracking which were relieved by the use of colorless lipstick. One can only suggest that this man's oral mucous membranes are like his skin, very sensitive to slight injury, or other irritations. All of these patients in Cases 7, 8, and 9 were uncooperative. They were positive about the state of their health, but it was impossible to obtain what we considered reliable information about it.

DISCUSSION

The cases described in this article illustrate the manner in which oral mucous membranes may respond to the irritation of dentures. One could substitute the words unequal pressure or trauma for irritation, but beyond that there is as yet

no more accurate definition for the etiology of the lesions. In Cases 1, 2, 3, 4, and 6, it is obvious that pressure is the etiologic factor. Whether this pressure is a direct rectangular stress or a rubbing, shearing type of stress has not been determined. An impression of the oral mucosa for the preparation of casts reproduces the natural irregularities found therein. It is presumed that the exact reproduction of these irregularities is necessary for good adhesion of the dentures. One can not help but wonder whether these irregularities do not in some instances account for the trauma.

In Cases 3 and 4, inflammation, though present, was not considered an essential part of the lesion. The swollen tissue which filled the outline of the vacuum chamber disappeared as soon as new dentures without chambers were worn. It was impossible to describe this change on the basis of histologic sections. It can be said, however, that vacuum chamber impressions are not necessarily the cause of inflammatory or nodular changes in the palatal mucosa.

The nodular appearance of the mucosa in Cases 8 and 9 was not changed materially when new dentures were worn. The inflammation accompanying these cases was reduced, but the nodular hyperplasia remained the same during the short postdelivery period they have been observed.

From our short experience with these cases, it is obvious that patients wearing dentures should be observed at least once every two years so that evidence of trauma can be relieved. There were no cases in the literature to show that any of these changes resulted in malignancy, but it is a well known fact that tissue inflammation in contact with bone will result in loss of bone. Since all of the lesions showed the presence of inflammation, every attempt should be made to reduce this entity under dentures. It is our opinion that dentures covering pathologic mucosa should be remade so that the adaptation and function can be made as nearly perfect as is possible. Where tissue inflammation and hyperplasia are present, the relining of a denture should not be considered. In other words, it takes more than proper denture base adaptation to maintain the health of the tissues. Dentures must not only fit correctly, but must also function correctly. It is not the material from which the denture is made that brings about mucous membrane pathosis. It is the type of contact with the mucosa that determines the type of mucous membrane response.

Amos* made a brief survey of the frequency of occurrence of palatal lesions associated with the wearing of dentures. He observed a total of 83 maxillary edentulous patients as they came through the examination room. There were 33 men and 50 women in the group; the former averaged 56 and the latter 48 years of age. There was clinically recognizable pathosis in the palates of 16 of the men and 22 of the women. In other words, about one-half of the patients wearing maxillary dentures showed evidence of palatal pathosis. The number of men and women was about equally divided. The average length of time that the affected patients had worn dentures was eight years.

*Dr. E. Amos, Department of Oral Diagnosis, University of Indiana School of Dentistry.

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INDIANA UNIVERSITY SCHOOL OF DENTISTRY
1121 W. MICHIGAN ST.
INDIANAPOLIS 2, IND.

THE OCCLUSION AND OCCLUSAL PATTERNS OF ARTIFICIAL POSTERIOR TEETH*

ROBERT RAPP, D.D.S.**

Toronto, Ontario

THIS ESSAY DEALS with the much debated problem in prosthetic dentistry of whether cusped, which are sometimes, perhaps erroneously, referred to as anatomic teeth, or flat, nonanatomic posterior teeth are more desirable in artificial dentures. This discussion, however, must and will cover a wider range of thought. It is essential to survey, not only the whole dentofacial area as well as the immediate tooth itself, but also the biologic factors involved. It is essential to familiarize ourselves with some of the laws which apply to the natural dentition so that we may ascertain whether or not they may be applied to artificial teeth.

A discussion of this type should be approached without bias, and this was the case when an investigation of the subject matter was begun. An intensive survey of the literature, however, has convinced me that considerably more evidence has been accumulated about the advantages of one type of tooth over the other. Therefore, the general conclusions drawn concerning this controversial problem may indicate a balance in favor of one side.

The prime purpose of providing the patient with dentures containing either anatomic or nonanatomic teeth is to provide an efficient and physiologic mechanism for the restoration and maintenance of oral health. In the past this problem has been attacked almost entirely from a mechanical point of view, the biologic side being grossly neglected. An analysis of the problem, as will be attempted in this paper, will indicate that a mechanical approach is vital provided that it is within biologic limits.

THE FORM OF THE ARTIFICIAL POSTERIOR TOOTH

A. Development of the Artificial Posterior Tooth.—

Until 1913 artificial posterior teeth were only approximately anatomic in form. According to Gysi they were "non-anatomical, had no definite cusp interdigitation and could be set one way as well as another."[1]

In 1913, Gysi carved his "normal-bite teeth," which originated from averages of his jaw recordings. These, however, did not function in crossbite relationships, so he later introduced his "crossbite teeth."

*One of two first prize-winning essays of the 1952 to 1953 American Denture Society Prosthetic Essay Contest for senior dental students.

**Senior student at the Faculty of Dentistry, University of Toronto (graduated in June, 1953) at the time this article was written.

In 1928, Sears presented his "Channel teeth," the first truly nonanatomically designed teeth. Their purpose was to provide efficient mastication and eliminate the shifting of dentures caused by anatomic forms. (Figs. 1 and 2).

Hall, in 1929, presented his nonanatomic "Inverted cusp" teeth. Their design was based on the principle of a cutting machine with two cusped disks rotating in opposing directions. The efficiency of these teeth is generally low as the inverted cusp will tend to clog with food (Fig. 3).

A short time later, Myerson marketed his "Trucusp teeth." These teeth had no cuspal inclinations, but had cutting blades and crushing tables carved in the occlusal surface, along with sluiceways for escape of the food.

Fig. 1.

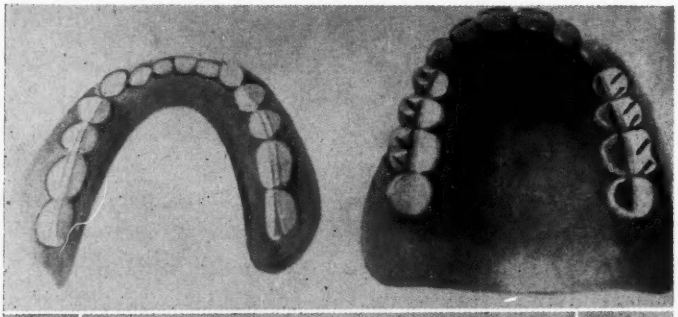


Fig. 2.

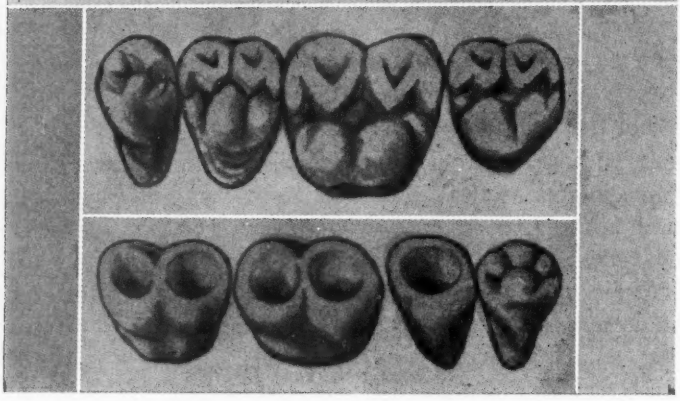


Fig. 3.

Fig. 1.—Sears' "channel teeth." (From Hardy, I. R. J. Pros. Den., January, 1951.)
Fig. 2.—Sears' "platform teeth." (From Hardy, J. Pros. Den.)
Fig. 3.—Hall's nonanatomic "inverted cusp" teeth. (From Hardy, J. Pros. Den.)

In 1935, French presented his nonanatomic teeth. He reasoned that natural teeth have a definite shape to function under natural conditions, while artificial teeth should be designed to function in those changed conditions found in the edentulous mouth (Fig. 4).

Swenson presented a tooth to improve upon Hall's theory. This was followed by a tooth designed by the Avery brothers. The next tooth form was designed by McGrane on a mathematical interpretation of anatomic features. These were not successful for they could not be readily adjusted to overcome cuspal interference with its accompanying damage to the underlying tissues (Fig. 5).

In 1946, Hardy introduced his "metal-insert teeth." These are plastic teeth with ribbons of metal inserted on the occlusal surface. Tests indicate that they are highly efficient[1] (Fig. 6).

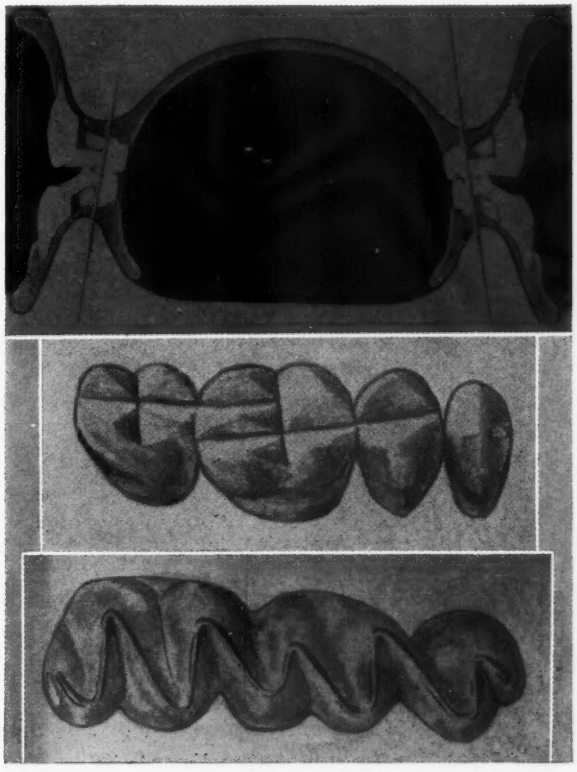


Fig. 4.

Fig. 5.

Fig. 6.

Fig. 4.—French's nonanatomic posterior teeth. (From Hardy, J. Pros. Den.)
Fig. 5.—McGrane's "curved cusp teeth." (From Hardy, J. Pros. Den.)
Fig. 6.—Occlusal view of Hardy's "metal-insert teeth." (From Hardy, J. Pros. Den.)

B. Why the Interest in Tooth Form? An Analysis of Edentulous and Dentulous Conditions.—

It is quite apparent that artificial dentures, as they exist today, inadequately fulfill their requirements. It is also apparent that a major objective in dental prosthesis is to restore and imitate the natural organs lost. To achieve this purpose most dentists use a Monson curve* and anatomically carved teeth. However, the efficiency achieved with the natural dentition is not nearly approached in the artificial. In an attempt to explain this loss of efficiency, let us examine the differences between the dentulous and edentulous mouth:

1. Individual tooth movement is possible in the natural dentition, but not in the artificial denture. Thus vertical or horizontal pressure on a natural tooth

*For discussion of the Monsoon Curve refer to p. 474, section D. Arrangement of the Teeth.

would affect only the individual tooth and the local surrounding tissue, while the same type of pressure on an artificial tooth in a denture would affect the entire denture, probably causing displacement.

2. Premature contact of a few natural teeth rarely has an immediate effect on the whole dentition, but premature contact of artificial teeth could dislodge the denture.

3. More pressure can be developed between natural teeth than between artificial teeth, and thus the efficiency of dentures is less. This may be due to sensory nerve endings, working in conjunction with proprioceptor and exteroceptor nerve mechanisms which are located in the soft tissue under the denture base protecting the patient from painful pressure. This is achieved either by lessening the pressure or moving the mandible to a new position of comfort, if it is found possible.

4. Retention and stability are different for both the natural and artificial dentitions. The natural is able to withstand tolerable force in all directions, whereas the only force which will not tend to dislodge a denture base is one where the direction is arranged in such a manner that tilting and gliding of the denture base on the mucosa is avoided.

5. Tooth wear in natural dentitions occurs where it is permitted by retention of abrasive elements in the food. This encourages a synchronization between the mandibular movement and tooth patterns. No changes occur in the denture unless the teeth are made from materials which are too soft to be of service for long periods of time, but changes do occur in the underlying tissues. This tends to throw the opposing teeth out of a harmonious relationship.

It is evident then, that if we attempt to duplicate the natural dentition we should also attempt to duplicate the features of retention, stability, biting force, and wear. This cannot be done. Therefore, because there are so many differences between natural and artificial, it is evident that alterations in denture construction are necessary. Specific designs on the occlusal surfaces of the teeth could be a good starting point.

C. The Anatomic Tooth Versus the Nonanatomic Tooth.—

1. *Basic Reasoning.*—The first approach to the problem has, therefore, resolved itself to an evaluation of the tooth itself. Our study of the differences between the edentulous and dentulous mouth indicates that a new condition has arisen in which the edentulous condition requires a new approach: a tooth which is designed for the special environment of the edentulous mouth and not one which is an imitation of a previously existing situation.

Definitions: An anatomic tooth is one carved to imitate the teeth seen in the mouths of recent man, having cusps and inclined planes on the occlusal surface. A nonanatomic tooth is one designed on a mechanical rather than anatomic basis, having a flat or nearly flat occlusal surface.

2. *Prehistoric Man.*—Studies of primitive man might reveal an approach to a proper tooth form.

> "It is only in recent centuries that man has ceased to wear off the cusps of his teeth."[2] When wear does occur and "when the softer dentin

> is reached it wears at a more rapid rate than the enamel. Hollows begin to form in the dentin, and inverted cusps, like those of Hall's artificial teeth, appear. These hollows become food escapes and the harder rims of enamel become cutting knives. The occlusal surface which becomes flattened permits a longer slide during the completion of the masticatory stroke, adding to shearing efficiency."[2] (Fig. 7.)

It is also my belief "that artificial teeth . . . should be devised and arranged to simulate the pattern created by wear."[2]

Studies also indicate that prehistoric men and modern men who exhibit wear on teeth with the consequent flat occlusal surfaces, end-to-end incisor relationship, and vertically directed force have teeth which last longer with better bone support.

> DeVan, in presenting anthropologic reports, writes: "There is little that is sanctimonious about the forms of our natural teeth, and the prosthetist, therefore, appears to be justified in exercising his mechanical sense in a search for forms of artificial teeth more conducive to the conservation of the hard tissue underneath artificial dentures."[3]

Fig. 7.—Teeth of primitive man showing wear, hollows in the dentine, and cutting edges of enamel. (From Moses, C. H., J. Dent. Med., October, 1952.)

From this it may be concluded that the forms we call anatomic are actually abnormal and pathogenic, while the flat teeth with cutting knives and food escapes are not only the correct forms but are physiologic.

On the other hand, however, McCollum and Schuyler, and M. Lean finally believe that the faults of anatomic teeth lie not in the tooth design but in their improper management.[4,5]

Thus, two schools of thought surround the subject, and evaluation of the evidence behind each is necessary in order to arrive at a proper conclusion.

It seems logical to believe, however, that a special tooth is required for the special condition found in the endentulous mouth. It might also be true that the form of this tooth need not be of the so-called anatomic pattern.

D. Specifications for Nonanatomic Artificial Posterior Teeth.[1,6]—

1. The working occlusal surfaces* should be void of cusps or inclined planes which would interfere with protrusive and lateral jaw movements[6] (Figs. 8 and 9).

2. The working occlusal surfaces should have at least 50 per cent of their area placed lingually to the ridge crest, with 100 per cent as the ideal. (Fig. 10).

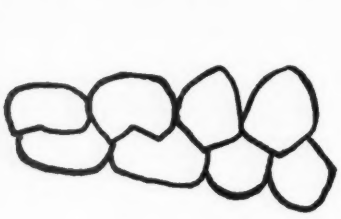


Fig. 8.

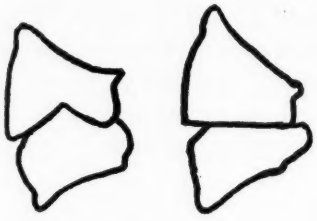


Fig. 9.

Fig. 8.—Interlocking of cusped anatomic teeth (lateral view). (From Sears, J. Pros. Den., May, 1952.)

Fig. 9.—Interlocking of cusped anatomic teeth and absence of this with nonanatomic teeth. (mesial view). (From Sears, J. Pros. Den., May, 1952.)

Fig. 10.

Fig. 11.

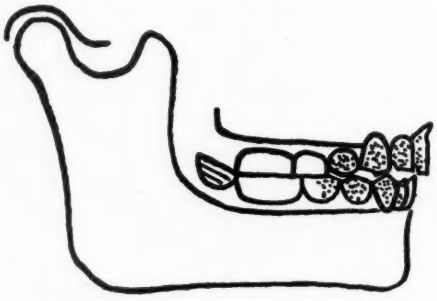


Fig. 12.

Fig. 10.—Placement of the bulk of the working occlusal surface lingual to the ridge crest. (From Sears, J. Pros. Den. May, 1952.)

Fig. 11.—With only the second bicuspid and first molar occluding in centric occlusion, the greatest load will fall on these teeth producing anteroposterior stability. The working occlusal surfaces lie parallel to the denture bases. (From Sears, J. Pros. Den., May, 1952.)

Fig. 12.—Various forms of occlusal surfaces, the dots indicating escapeways for food. (From Sears, J. Pros. Den., May, 1952.)

3. The working occlusal surfaces should be placed in such a way that they lie parallel to the ridges, so that the greatest load falls at a desired mesiodistal point. This will prevent anteroposterior tilting and any horizontal thrust due to inclined plane action (Fig. 11).

*Sears designates the working occlusal surface as that part of the occlusal surface used for mastication and the balancing occlusal surfaces as that part used to obtain occlusal balance.

4. The working occlusal surfaces should have their combined area in proper proportion to the supporting value of the tissue.

5. The working occlusal surfaces should be at right angles to the direction of closing force.

6. The teeth should be designed in such a manner that if altered by grinding they would not lose their mechanical or esthetic value.

7. There should be no wells, hollows, or traps into which food can pack, all major depressions having escapeways (Fig. 12).

8. Balancing occlusal surfaces should be available to provide bilateral balance simultaneously in all movements without sacrificing the ideal angle of any portion of the working occlusal surface (Figs. 13 and 14).

9. The balancing occlusal surfaces should be used only for balancing and not for function as in the case of anatomic teeth.

10. The balancing occlusal surfaces should be adjustable without causing changes in the buccal, lingual, and working occlusal surfaces or other balancing occlusal surfaces.

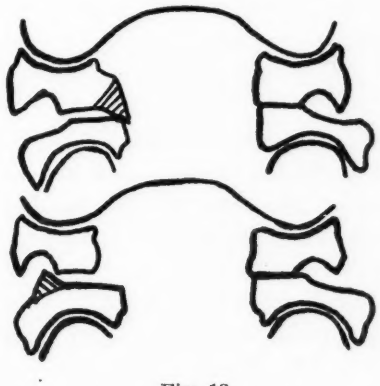


Fig. 13.

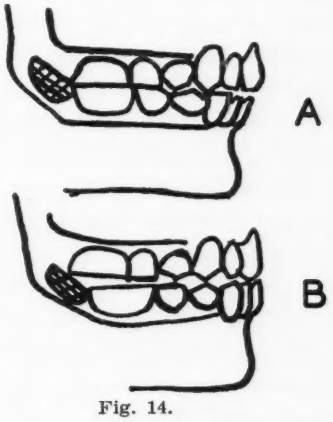


Fig. 14.

Fig. 13.—Balancing occlusal surfaces providing balance in lateral jaw positions. (From Sears, J. Pros. Den., May, 1952.)

Fig. 14.—*A*, Position of the teeth in centric occlusion. *B*, Balancing occlusal surfaces providing balance in the protrusive jaw position. (From Sears, J. Pros. Den., May, 1952.)

11. The buccal surfaces should be such that they fulfill esthetic requirements as well as provide sufficient contacts with the cheeks to fill the buccal vestibules; however, they should not cause biting of the cheeks.

12. The lingual surface should make sufficient contact with the tongue during eating and speaking, but it should not cause tongue biting or constriction.

13. It should be possible to arrange the teeth in crossbite relationship if required.

14. The arrangement of the posterior teeth should not interfere with arrangement of the anterior teeth.

15. The teeth should be efficient when in function.

16. That portion of the occlusal surfaces which provides masticatory function should be composed of a relatively wear-resistant material.

E. Factors Influencing Function of Anatomic and Nonanatomic Teeth.—

1. *Efficiency.*—Efficiency has been defined as the ability to produce results. This is applicable to denture function, the aim of mastication being the comminution of food. One controversy between anatomic and nonanatomic tooth design concerns the relative efficiency of the two forms.

Influencing efficiency are many factors other than the teeth themselves, such as: (a) the type of patient, (b) the condition of the mucosa and bony ridge, (c) the type of denture, (d) the biting force, (e) the character of the food and size of bolus, and (f) the arrangement of the teeth.

Many tests have been performed which have taken into consideration these influencing factors, thus obtaining a fair evaluation of the efficiency of the tooth type itself.

Manly and Vinton[7] determined that the artificial denture is, on the average, only 25 per cent as efficient as the natural dentition, and that "there is a slight indication that performance with a nonanatomic tooth is greater than that with the anatomic tooth."

Thompson[8] found, in a series of tests, that 33 degree anatomic teeth were 65 per cent efficient, 20 degree teeth 57 per cent efficient, Hall's teeth 56 per cent efficient, and Sears' Channel teeth 29 per cent efficient.

Payne,[9] when testing 33 degree anatomic teeth and flat, nonanatomic teeth, on duplicate denture bases, found that cusped teeth were the more efficient of the two types. Patients felt cusps were slightly more efficient than flat surfaces, although the eventual difference tended to be minor.

Schuyler[5] indicates that anatomic teeth are more efficient as the double cutting cusps not only shear as the mandible passes from eccentric to centric position but mash as centric occlusion is approached.

Schultz[10] estimates that 32 per cent efficiency is lost when a lingual cusp is ground to provide balance, and 26 to 33 per cent efficiency is lost when acrylic teeth are used rather than porcelain.

French[11] concludes that if efficiency were the only factor in denture construction, properly balanced anatomic teeth would be in order, but other factors exist in which cusps are not indicated.

Thus, the general indication is that the cusped, anatomic tooth is slightly more efficient than the flat, nonanatomic tooth.

Efficiency is also influenced by the type of masticatory movement permitted by the tooth. Payne[9] found that mandibular movements follow the occlusal surfaces of the teeth present in the mouth, and indicates that nonanatomic teeth allow greater lateral mandibular excursions. A greater mandibular excursion should produce an increase in shearing action and chewing efficiency. Even if cusped teeth are more efficient than flat teeth, the advantage gained by their use could be offset by their restriction of lateral and protrusive jaw movements which occurs if they are not properly balanced. It has also been questioned whether or not the lateral thrust set up by cusps on artificial teeth is sufficiently harmful to warrant their elimination and the use of the less efficient cuspless teeth. Moses[13] thinks that the elimination of cusps and the consequent reduction in efficiency is compensated for by the longer glide permitted by the flat teeth.

2. *Directional Forces.*—Periodontists claim that the direction of force on the natural tooth should fall along its long axis. Forces on dentures must be in a direction which will give the greatest stability. This is accomplished by: (1) the form of the tooth, (2) the placement of the tooth, and (3) the arrangement of the teeth.

(1) Form of the tooth: A flat occlusal surface makes it relatively simple not only to direct the force of mastication where it is desired, but to eliminate any resultant horizontal stresses. The proponents of the anatomic teeth, however, claim that it is not the presence of the cusp that influences direction of force, but the mismanagement of these cusps.

One of the greatest objections to the use of anatomic teeth is the difficulty to maintain them in occlusal balance after dentures are inserted in the mouth. This is due to dentures "settling" because of alteration of tissues under the denture base. A new denture position is then produced with a resulting change in the prearranged directional force. Cusps tend to cause anteroposterior locking which prevents the dentures from moving to their new position of directional force, thus resulting in a loss of stability. The forces are also redistributed, sometimes causing excessive pressure in certain areas with a resulting resorption of portions of the ridge. This in turn causes further malalignment of the dentures.

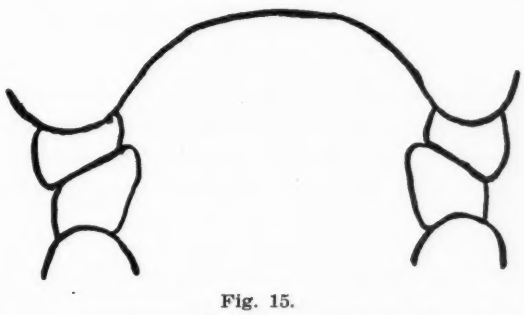


Fig. 15.

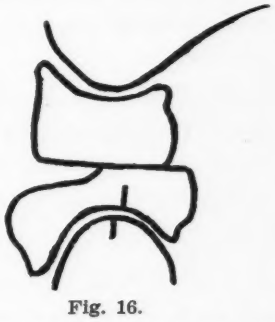


Fig. 16.

Fig. 15.—Arrangement of the occlusal surfaces of teeth to direct the forces of occlusion lingual to the lower ridge. (From Sears, J.A.D.A., November, 1948.)

Fig. 16.—Placement of the working occlusal surface lingual to the lower ridge crest to control directional forces. (From Sears, J.A.D.A.)

The nonanatomic tooth is easier to arrange and maintain in proper line of force under similar conditions.

(2) Placement of the tooth: Due to the greater retention of the upper denture, any mismanagement of directional forces tends to occur at the expense of the lower, producing an unstable lower replacement. Forces directed to fall inside the lower ridge create increased stability (Figs. 15 and 16). This can be accomplished by placing the lower tooth lingual to the lower ridge and/or tilting the tooth so that force is directed lingually. Of course, there are contraindications. When the retention of the upper denture becomes a problem due to its small area or ridge form, it may be necessary to use the standard Monson type of tooth arrangement. Also tongue room should be maintained. Crowding may cause the intrinsic muscles of the tongue to be maintained in a constant state of con-

traction with injurious consequences. Also this may introduce forces which may lift or displace the lower denture.

3. Horizontal Stress.—When a vertical force is applied to an inclined plane, nonvertical forces or horizontal stresses appear.

It is essential to minimize horizontal stress on dentures for the maintenance of oral comfort, health, and denture service. The proponents of flat teeth claim that cusps cause this particular stress, whereas Schuyler[5] maintains that the inclination of the eminentia articularis portion of the mandibular fossa, along with the incisal guidance, and not the tooth forms govern horizontal stress. In other words, a cusped posterior tooth, as long as it conforms to these factors, will not cause denture movement. Shallow incisal guidance together with a shallow condylar inclination demands flatter posterior teeth, while steep incisal guidance and a steep condylar incline demand steeper cusped teeth. Schuyler further indicates that a steep incisal guidance is contraindicated because it demands steep tooth inclines the presence of which contribute to rapid alveolar resorption. Only by the reduction of incisal guidance is it possible to reduce cuspal inclines, thus controlling horizontal stress. Therefore, it is not only the cusps causing bone resorption, but also the unconformed incisal guidance which necessitates cusps for balance. He is also of the opinion that it is harder to reduce incisal guidance with nonanatomic teeth than with anatomic as they rely on the curve of Spee for stability rather than cuspal inclines.

4. Stability.—Denture stability is the ability of the denture to remain in position during masticatory and nonmasticatory movements. Factors influencing stability are: (1) tooth form, (2) tooth arrangement, (3) jaw movements, and (4) impression technique. Tissue may be displaced sufficiently to upset stability by tending to resume its undistorted form.

(1) Tooth form: Schuyler[5] claims that denture stability, from the standpoint of tooth form, is no more favorable with one form than with another, the incisal guidance being the only controlling factor.

The following are the arguments used by proponents of nonanatomic teeth: 1. It is difficult to balance cusped teeth. This is, of course, not a valid argument, yet the problem remains. 2. Rarely are cusped teeth balanced. 3. Tissues are not static, but are always changing. These tissue changes occur more under cusped teeth, particularly those which are unbalanced, with the end result being that flat teeth are preferable.

It is more advantageous to have contact with flat surfaces than to have improper interdigitation of the opposing inclined planes.

If the occlusal balance is not perfect, the misplaced inclined planes striking upon each other will cause denture base movement with loss of stability and tissue resorption.

In order to avoid confusion, it must be clarified at this point that Schuyler, although a proponent of the anatomic tooth, feels that an overly steep cusp is harmful, a modified anatomic form being the correct tooth to use.

F. Summary.—

The Form of the Artificial Posterior Tooth.—A discussion of anatomic and nonanatomic posterior teeth which centered around the individual tooth has been presented. The influencing factors on the tooth, as well as the immediate form of the tooth, were acknowledged.

1. The more recent trend is toward the development of nonanatomic tooth forms.
2. The edentulous mouth requires a tooth designed to suit its own specific needs.
3. Nature shows that wear on teeth is normal thus indicating a flat, "nonanatomic" tooth to be the true anatomic pattern.
4. If a new tooth is to be developed, it must comply to definite specifications for maximum success.
5. Efficiency, directional force, horizontal stress, and denture stability are all affected by the function of the two tooth forms. However, with the exception of efficiency, nonanatomic forms can cope with the previously mentioned factors more efficiently than the anatomic forms. Anatomic teeth are more efficient than most nonanatomic teeth.

Generally, the proponents of the anatomic tooth believe that cusped forms are better because they (1) imitate nature, (2) look better due to natural shape, (3) are efficient, (4) provide efficient occlusal balance, and (5) can be made to conform to mandibular movements.

Similarly, the proponents of the nonanatomic tooth advocated their forms because they: (1) do not cause denture movement and resorption of the tissues, (2) are easier to balance, (3) are relatively efficient, and (4) are easily conformed to jaw movements.

THE PATTERN OF THE OCCLUDING AREAS OF ARTIFICIAL POSTERIOR TEETH

A. Introduction.—

This discussion will evaluate the artificial posterior teeth as one unit under the influence of jaw movements. This is in contrast to the previous discussion which dealt with the tooth as a single entity.

The teeth contained in a denture should be mechanical in nature as a denture is a mechanical replacement of lost natural forms. The denture should be under the guidance of physical laws as well as being influenced by biologic forces.

B. Mandibular Movements.—

Simple mandibular motions of opening and closing would produce a chopping action. Human jaw movements are made more complex because of the nature of human food elements. For denture success through the medium of artificial teeth, it is essential that the teeth conform to a great variety of movements. According to Shanahan,[18] "If the cusps of full denture teeth are not conformed to cyclic movements, the denture will be subjected to traumatic lateral thrusts through premature contacts."

Many studies of mandibular movements have been made such as condyle path and occlusal path records. Perhaps the more notable of these have been those of Hildebrand and Kurth. For this study, let us begin by differentiating between the masticatory stroke and the nonmasticatory stroke. 1. The masticatory stroke includes incision, shearing, and grinding. 2. The nonmasticatory stroke includes talking, swallowing, yawning, and coughing.

1. Masticatory Movements.—This phase of jaw movement contains two divisions: (1) opening, and (2) closing. The opening phase, according to Boswell, is composed of a composite downward and lateral motion of the mandible for the introduction of food into the mouth and placement of this food upon the occlusal surfaces of the teeth by the cheeks and tongue (Fig. 18).

The closing phase is also a composite movement being composed of an upward motion which is initially directed outward and finally inward until the teeth meet and slide into centric occlusion. (Fig. 18).

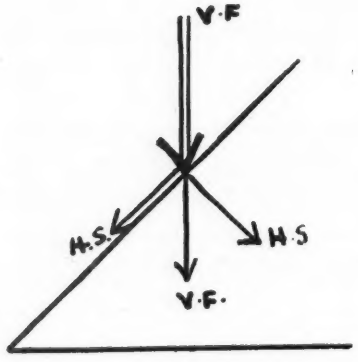


Fig. 17.

Fig. 18.

Fig. 17.—The development of nonvertical forces when a vertical force is applied to an inclined plane.

Fig. 18.—Tracings of jaw movements to show the downward and lateral components of the opening phase and the upward and inward components of the closing phase. (Boswell, J. V., D. Survey, June, 1951.)

Due to the presence of food between the teeth during the closing masticatory movements, there is an increase in pressure of the stroke with the development of dislodging forces on the denture. For the elimination of these forces, it is essential that the arrangement of the teeth directs the pressure in a direction which will minimize these adverse forces. Balanced occlusion, in this situation, does not help to maintain stability as the dislodging forces arise before occlusion is reached.

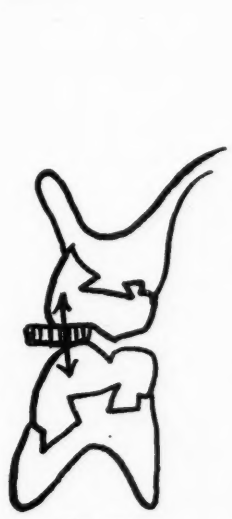
2. Nonmasticatory Movements.—The importance of nonmasticatory movements has been little appreciated. Food in this phase of jaw motion is absent, and if cusps which have become malarticulated are present, lateral force is introduced which tends to produce a horizontal thrust to the denture bases. Cuspless

teeth without inclined planes would minimize this effect, as they tend to convert horizontal forces into a vertical direction.

C. Directional Forces as Influenced by Tooth Arrangement.—As already indicated, the masticatory movement creates forces not accounted for on the articulator. Thus, dislodging interferences are eliminated at centric occlusion, but not at or just prior to positions of occlusal balance.

> Pleasure[14] adds that, " . . . the resultant forces that chewing pressure generates in the occlusal plane are the active causes of the lateral stresses which force the dentures to shift and traumatize the alveolar mucosa. It is these resultants, which have not been eliminated by the adaptable articulators, spot-grinding or the use of non-anatomic tooth forms."

Therefore, it must be realized that it is necessary to control forces before dentures reach occlusal contact, as well as to control them in centric and eccentric positions.



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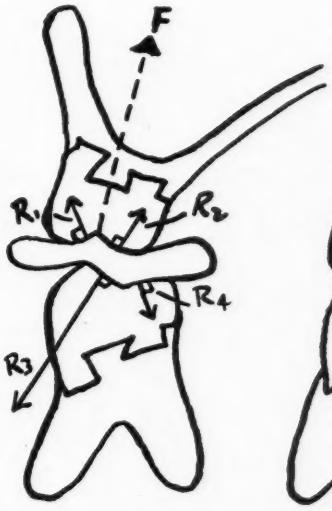

Fig. 20.

Fig. 21.

Fig. 19.—A diagram used to illustrate the forces set up during mastication. (From Pleasure, M. A., J.A.D.A., August, 1937.)

Fig. 20.—The forces of mastication. (From Pleasure, J.A.D.A.)

Fig. 21.—The food space which forms at a certain mandibular position. (From Pleasure, J.A.D.A.)

1. Analysis of Forces Produced During Mastication.—(a) *Lateral forces:* Fig. 19 is the one usually used to explain biting forces set up during function. It indicates only the primary force and not the resultant forces caused by inclined planes of occlusal surfaces. Fig. 20 shows all the forces on a tooth as caused by mastication. F is the direction of movement of the mandible and therefore the primary line of force. R_1 and R_2 are the most important and powerful resultants as they arise nearly at right angles to the primary force. R_1 is desirable as it tends to seat the upper denture, thereby stabilizing it. R_2 shows the adverse effects of high buccal cusps on the lower denture. The factors that oppose tilting of the

lower denture are atmospheric pressure and interfacial surface tension, which are usually inadequate. A rectangular space, which can be closely packed with food, forms as the teeth reach the working bite position (Fig. 21). As the teeth close, the pressure on the food becomes greater, existing equally in all directions. This exists until the upper buccal and lower lingual boundaries decrease in size, the lower buccal and upper lingual boundaries remaining the same. Thus, more force develops against the lower buccal and upper lingual cusps which produces tilting of the lower denture. According to Pleasure,[14] balanced contacts on the other side may help prevent buccal tilting but cannot prevent a slight lateral shift of the entire lower denture.

(b) *Anteroposterior forces:* Fig. 22 illustrates that with the more retentive upper denture and the upward, forward movement of the mandible, the action of the interfering cusps would tend to move the lower, less stable, denture backward and downward. According to Fish,[15] the most beneficial forces to act on the posterior teeth for matters of stability are those which act upward and backward on the uppers and downward and forward on the lowers. The use of teeth with flat occlusal surfaces would facilitate the production of force in the directions outlined by Fish.

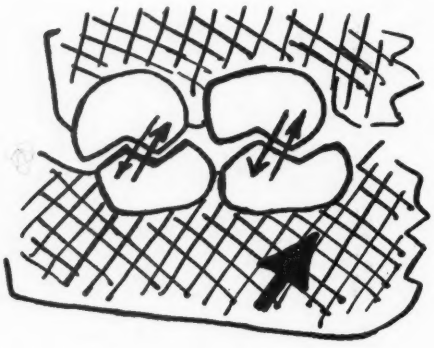

Fig. 22.

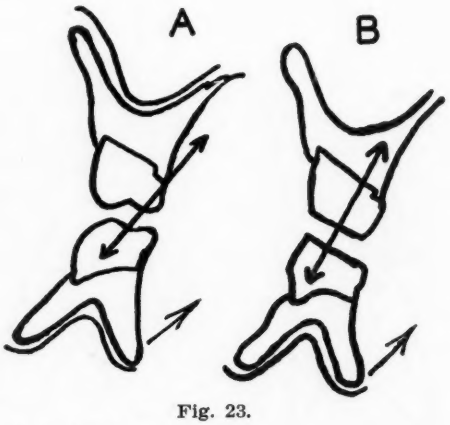

Fig. 23.

Fig. 22.—The anteroposterior forces produced during jaw closure.
Fig. 23.—The tilting effect of the Monson tooth arrangement on the lower denture with *(A)* anatomic teeth, and *(B)* nonanatomic teeth. (From Boswell, J. V., D. Survey, June, 1951.)

Sears[16] claims that the optimal condition with forces exists when they are directed at right angles to the occlusal surfaces (which should be parallel to the ridges) and fall on that portion of the teeth which lies lingual to the ridge crest, the point of application being at the center of the denture foundation mesiodistally and buccolingually.

D. Arrangement of the Teeth.—

1. Viewed Frontally.—(a) *Monson Pitch* of the occlusal surfaces:* The Monson theory of tooth arrangement has the lower buccal cusps higher than the

*The word pitch, as used here, will refer to the direction of inclination of an occlusal surface. The Monson pitch will "denote the generally accepted pattern of the occlusal pitch." The anti-Monson pitch refers to the opposite direction of occlusal inclination.[12]

lingual forming a concavity with a radius of four inches. This arrangement tends to produce a tilting effect on the lower denture, even when cuspless teeth are used. It would also tend to produce cuspal interference with anatomic teeth (Fig. 23).

(b) *Anti-Monson pitch of the occlusal surfaces:* It is argued that the Monson curve is the tooth arrangement found in nature and, consequently, along with the anatomic tooth, should be adhered to. Moses indicates, however, from studies of primitive skulls that Monson was not entirely correct; there is evidence of tooth arrangement with anti-Monson pitch and flat teeth (Fig. 24). The conditions governing the occurrence of these two types are defined by Moses' law which states that, "Under normal conditions a natural posterior tooth inclines in the direction of the ridge opposing it."[12]

Therefore, realizing the fallacy of complete adherence to Monson's observations and also the fact that artificial teeth are mechanical devices responsive to mechanical principles as well as biologic laws, why not arrange the teeth to suit our purpose of improved function?

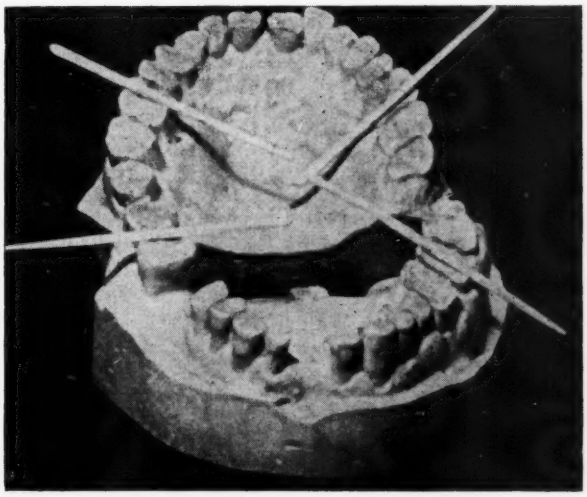

Fig. 24.

Fig. 25.

Fig. 24.—Eskimo teeth showing flat occlusal surfaces and anti-Monson pitch. (From Moses, C. H., Dental Items Interest, October, 1946.)
Fig. 25.—Nonanatomic teeth set in an anti-Monson arrangement to provide stability to the lower denture and less trauma to the ridges. (From Boswell, J. V., D. Survey, June, 1951.)

As the mandible in function, viewed frontally, produces an upward and inward force simultaneously with production of an equal and opposite downward outward dislodging force, would it not seem logical to set flat teeth in an anti-Monson arrangement to obtain less bone destruction and stabilization of the lower denture? (Fig. 25.)

2. *Viewed Sagittally.*—Sears[16] is of the opinion that the forward movement of the mandible seen during resorption of alveolar bone should be prevented. To accomplish this, he suggests that the occlusal plane be placed high at its posterior

end. This would prevent anteriorly directed mandibular drift and would increase the stabilizing forces as indicated by Fish[15] (Fig. 26).

However, it is doubtful whether the mandible actually drifts forward. If it be true, as many men claim, that there is a hinge axis of opening movement which is relatively fixed, increased closure, as in the case of resorption, would bring the chin more forward. This has been frequently misinterpreted as a forward movement of the mandible (Fig. 27).

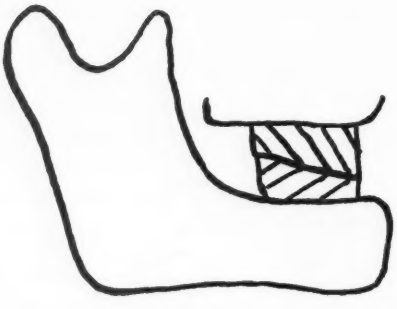

Fig. 26.

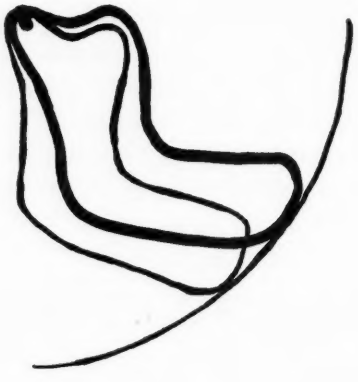

Fig. 27.

Fig. 26.—The placement of the occlusal surfaces, as advocated by Sears, to prevent forward movement of the mandible during resorption of the ridges. (From Sears, J.A.D.A., November, 1948).

Fig. 27.—The method in which the mandible can move forward upon loss of vertical dimension during resorption of alveolar bone. This is based on the theory of the hinge axis of movement.

When resorption of the ridges does occur, decreasing the vertical opening of the jaws, nonanatomic teeth permit the mandible to move to its new position of minimal shifting of denture bases. This will be anterior to the previous one due to the upward and forward direction of jaw closure (which is controlled by the hinge axis). Not only do anatomic teeth interfere with this movement, but they fail to hold the mandible back in its original position.

E. Mandibular Drift as Influenced by Anatomic Teeth.—It is assumed that dentures are at correct centric occlusion and occlusal balance when they are inserted in the mouth. As resorption of the ridges occurs, especially the lower, there is a decrease in the vertical dimension. This, as has been explained, causes the chin point to move in an upward, forward direction. If the denture has anatomic teeth, cuspal interferences will occur. This interference produces skidding of the denture base, which causes trauma and increased ridge resorption. Gysi, who believed that the entire mandible actually moved forward, claimed that cusps prevented this anterior movement. Of course, the results were often disastrous.

Occlusion would not be as seriously affected if nonanatomic teeth were used. They would permit the mandible to assume its new position of centric occlusion without traumatic interference.

Kurth[17] evidently believes that the mandible drifts forward also, but claims that the addition of cusps will not stop this anterior drift, as the teeth are only in masticatory contact one hour in twenty-four, the rest of the time the mandible being in a position of physiologic rest.

F. Maintenance of Ridge Tissue Under Influence of Artificial Teeth.—Properly balanced anatomic teeth set in correct centric occlusion will, theoretically, cause little trauma to tissues. Cuspal interferences anteroposteriorly and buccolingually, which can occur where these teeth are improperly arranged, can cause a shifting of the dentures and a destruction of the underlying ridge tissue.

On the other hand, cuspless teeth with their lack of interfering cusps, are more likely to maintain their efficiency without damage to the ridge tissues. Proof of flatly worn natural teeth to have heavier bone formation is borne out by Moses.[3]

G. Radical Changes in Tooth Form.—

1. Sears' Chewing Members.—Sears is of the opinion that deviations from anatomic forms are justifiable if the substitute produces efficient mastication with a minimum of damage or change in appearance. With this in mind, he devised nonanatomic teeth built in blocks rather than single units. An upper and lower artificial posterior dentition of this design contains four blocks, a block being composed of two bicuspids and two molars. Sears claims that these teeth are: (1) efficient, having fairly steep inclined planes, (2) less traumatic in nature as the antagonists glide smoothly over each other instead of interfering as seen in protrusive and lateral movements with cusped teeth, (3) easier to set up, and (4) adequate in appearance. If thought too conspicuous, one or two anatomic teeth can be replaced in a block.

2. Hardy's "Metal Insert" Teeth.—Hardy's "metal insert" teeth represent a change of emphasis in tooth design. He devised his teeth basically for obtaining efficiency in mastication. This tooth form in occlusal outline is similar to the other types except that it is composed of one block of plastic with imbedded undulating strips of metal. Efficiency is very high. These teeth are useful with patients who have heavy bites that fracture porcelain teeth or wear plastic teeth.

H. Esthetics, Comfort, and Size of Artificial Posterior Tooth.—

Esthetics.—The deviation from the natural form of the occlusal surface will cause a change in appearance of the nonanatomic teeth. The buccal and lingual surfaces of these teeth can resemble those of the natural dentition, thereby leaving only the occlusal surfaces with the new form. The area of the occlusal surface which comes into view is quite small. The important consideration is not the loss of esthetics but the improvement of oral conditions.

Comfort.—Comfort to denture patients seems to be greater with flat teeth as the movement of the denture bases caused by anatomic teeth is reduced in the masticatory and nonmasticatory movements.

Size of the Tooth.—The area of the occlusal surface of any artificial posterior tooth form is important. The smaller an occlusal surface, the greater the ease of penetration and the less the resulting pressure on the supporting tissues.

A clinical and radiographic examination of the supporting tissues will provide an estimation of the tissue tolerance and will facilitate the selection of the proper type of tooth.

I. Indications for Use of Anatomic and Nonanatomic Artificial Posterior Teeth.—The problem arises as to whether one type of tooth should be used routinely or whether an evaluation of the existing oral conditions should be made to determine if an anatomic or nonanatomic tooth is indicated.

Payne[18] indicates that flat teeth be used (1) where ridges are flat, rendering dentures more susceptible to horizontal stress, (2) in old age (where *1* usually exists), (3) when the vertical dimension is great which would cause tipping forces to develop, and (4) if a maximum of vertical force and a minimum of horizontal stress is desired. He feels cusped teeth should be used (1) where good ridge exists, and (2) with younger people (where *1* usually exists).

Shanahan suggests that the general rule, "High cusps for the young and low or flat cusps for the aging" be the criteria of tooth selection.[18]

In the case of the young patient or patient with high, well-formed ridges, the selection of anatomic teeth for the prime sake of efficiency is, in my opinion, poor practice. Even though the anatomic tooth is considered by some to be more efficient, it also has been demonstrated that its efficiency is not superior to that of flat teeth to a very marked degree. And more important, it may be concluded that ridge destruction is greater with cusped teeth. Therefore, it seems logical to forego the advantage of slightly increased efficiency with the anatomic tooth for the greater advantage of ridge-preserving quality of the nonanatomic tooth.

J. Summary.—

Artificial posterior teeth have been evaluated as units opposing each other, which is in contrast to the consideration of individual tooth form.

1. Mandibular movements may be separated into masticatory and nonmasticatory components. Tooth form and arrangement must conform to these movements, the nonanatomic tooth being the more suitable.

2. Pressures on the teeth may create resultant or horizontal stresses which must be controlled. Forces set up during nonmasticatory movements can be better controlled by using nonanatomic teeth arranged on an anatomic articulator. The stresses occurring during masticatory movements cannot be controlled in the same manner since food between the teeth prevents occlusal balance. Flat teeth arranged so that force is directed lingual to lower ridge crest give better control of stress.

3. The "natural" arrangement of teeth as specified by Monson does not take into account all the known tooth arrangements and does not produce the maximum

degree of stability in dentures. The anti-Monson arrangement, combined with nonanatomic teeth, is preferable.

4. Nonanatomic teeth, due to lack of cuspal locking, permit the mandible to assume its new position of occlusion with less displacement of the dentures as resorption changes the vertical dimension. The direction of force on these malaligned dentures is more vertical and less horizontal than with cuspal teeth. There is, of course, less trauma to underlying tissues.

Cusped teeth do not lock the mandible in position nor do they prevent the dentures from shifting when changes in vertical dimension occur.

5. There is less resorption of the ridge tissue when flat cusped teeth are used.

6. Sears' and Hardy's change of the conventional tooth form might, after further study and improvement, prove to be most beneficial.

7. Esthetics is reduced in the use of nonanatomic teeth, but the comfort is increased.

8. The size of the occlusal surface of the artificial posterior teeth must be in harmony with tissue tolerance to avoid tissue destruction.

9. Nonanatomic teeth are indicated for high, well-developed ridges as well as the low, flat ridges.

CONCLUSIONS

There are many tooth forms, both anatomic and nonanatomic in design. It is obvious that some are better than others, regardless of the type chosen, but of the two basic types, the nonanatomic tooth seems to be the one of choice. The real choice, however, is not so much which of the two types is the more effective, but which of the nonanatomic teeth is the more suitable.

When the natural teeth are lost, their replacement becomes a mechanical problem, and within physiologic limits, must be treated by mechanical methods and forms conforming to physical laws.

Our concepts of the natural oral conditions, many of which were formulated years ago, must undergo examination in order that their validity may be tested. The discovery that there is a fallacy in the concept of the all inclusive tooth arrangement as presented by Monson is a result of such action.

It is only in recent years that the problem of tooth replacement has been attacked in a more scientific manner. Clinical observations are important, but they must be borne out by exacting scientific research. Such an approach will elevate the dentist, making him less of a technician and more of a professional man, trained in the healing arts and rendering a professional service.

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The Hospital for Sick Children
555 University Ave.
Toronto 2, Ont.

FULL DENTURE PROSTHESIS IN THE PRESENCE OF ADVANCED PAGET'S DISEASE

ELMAR A. SIEGEL, D.D.S.*

Lyons, N. J.

A COMPLETE DENTAL service in a hospital frequently faces problems that seldom arise in a private practice. Although the construction of a full denture for a patient with advanced Paget's disease probably falls into such a classification, the primary prosthodontic problem presented by such a patient conceivably warrants the report of such a case.

Paget's disease, or osteitis deformans, first described by Paget in 1877, is a localized bone disorder, and as such may be limited to one bone or widely spread through many bones. Although lesions may be similar to, and must be differentiated from, lesions of hyperparathyroidism, particularly osteitis fibrosa cystica, there is strong evidence that it is neither a metabolic nor an endocrinologic disorder.[1] Radiographic examination of affected bone reveals a typical cotton wool appearance[2] produced by simultaneous activity of osteoclasts producing cystlike lesions, and osteoblasts laying down overly dense bone with atypical trabeculae (Figs. 1, 2, and 3). The bones affected seem to be those most subject to stress. Thus, the pelvis is usually the first to be involved. The bones of the lower extremities are more frequently involved than those of the upper extremities. It is thought that the bones of the skull are involved because of the pull of the temporal muscles, and probably the galea aponeurotica. The only apparent involvment of teeth seems to be hypercementosis with resorption. Paget's disease produces both thickening and deformities of the affected bones until finally the skeletal frame is unable to support the patient's weight. Fractures may occur and the patient may become a wheel-chair invalid. Immobilization is usually accompanied by continued bone destruction without the stimulus necessary for producing bone formation. As a result, serum calcium, which is usually undisturbed, rises and serum phosphatase falls markedly.

Symptomatically, Paget's disease is characterized by pain in the affected bones that may be described as rheumatic, gouty, or neuralgic; it is not accompanied by fever.[3]

There is presently no therapeutic approach which offers promise of cure, nor is the course of the disease affected by any known treatment.[4] Nevertheless, in some patients, the disease seems to go into spontaneous remission, or has periods of apparently long quiescence. Because of the softening of the bone due to resorption, fractures of long bones are not uncommon in advanced Paget's disease.

Conclusions expressed in this article are those of the author and do not necessarily reflect the opinion or policy of the Veterans Administration.

Received for publication Oct. 8, 1953.

*Chief, Dental Service, Veterans Administration Hospital.

Fig. 1.—Posteroanterior radiograph of skull, showing typical cotton wool appearance in advanced Paget's disease. The width of the maxilla is apparent.

Fig. 2.—Lateral radiograph of the skull. Thickening of the plates and sclerosis is apparent.

Evidence of extreme overcalcification at such sites as well as histories of union more rapid than normal is of frequent occurrence.

Fig. 3.—Posteroanterior radiograph of the pelvis. Note the involvement of advanced Paget's disease.

CASE REPORT

A white man, aged 58 years, was referred to the dental service at this hospital for examination and evaluation for the construction of full dentures. The staff diagnosis was Paget's disease with psychosis, psychosis in remission. Upon admission in 1945, the patient's height was five feet. He claimed he had been taller, and he claimed he had noticed his head had been getting larger since 1933; since that time he had had to purchase progressively larger sized hats. The diagnosis of Paget's disease was first made subsequent to a hospital admission in 1943. Present height is four feet, nine inches, and the loss in height is assumed to be due to compression fractures of the vertebrae and bowing of the leg. Mental and other physical findings are irrelevant.

Dental examination revealed a wheel-chair invalid, extremely short, with an extremely large head. Intraoral examination revealed an edentulous mouth. The maxilla was wide from ridge crest to ridge crest, and each ridge crest was also wider than normal. The ridges were low except in the regions of the tuberosities where they were both very high and bulbous, almost completely filling the buccal pouches (Figs. 4, 5, and 6). The soft tissues covering the ridge were apparently of slightly less than normal thickness and evenly distributed over dense bone. The denture-bearing area of the mandible was equally low and wide, and covered with thin, firmly adherent mucous membrane. Tissue was firm and hard over the retromolar pad. The patient's tongue was large, stiff, and extremely difficult to push aside digitally. Saliva was of normal viscosity and quantity. The two major findings revealed at examination which affected the prognosis adversely were: (1) overdevelopment of the tuberosities, and (2) the large, tough tongue which so completely filled the mouth. The medical service,

in consultation, recommended that surgery to reduce the tuberosities be avoided. The possibility of resorption and subsequent overcalcification could probably result in the development of tuberosities larger than those now present.

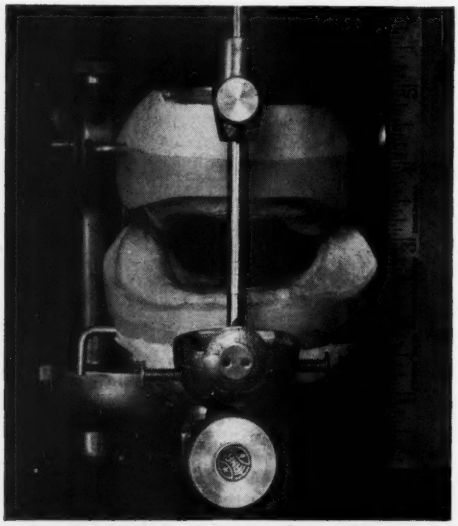

Fig. 4.—Casts mounted on the articulator. The extreme width of the arches is apparent.

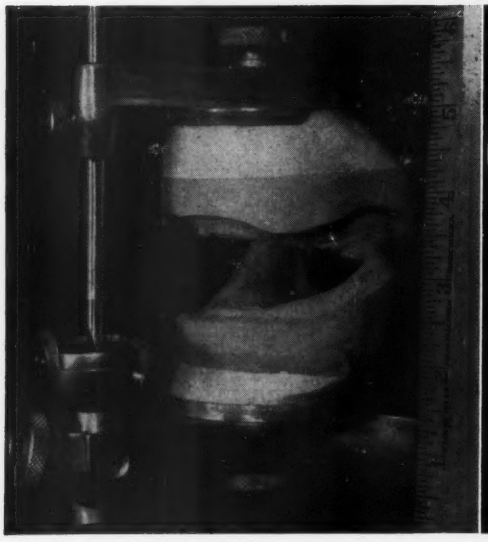

Fig. 5.

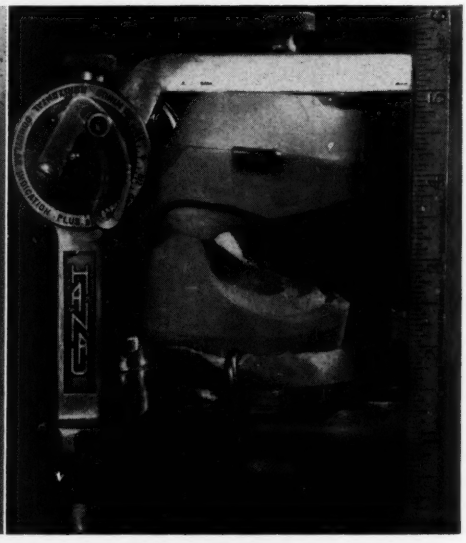

Fig. 6.

Fig. 5.—Lateral view of mounted casts. Note the bulbous tuberosities and the close approximation of the tuberosity to the mandibular retromolar pad.

Fig. 6.—Lateral view of the casts. Phonation tests indicate an adequate interocclusal rest space.

The history, partially from old hospital records and partially from the patient, revealed that upon admission in 1945, he had been partially edentulous without partial dentures. The remaining teeth were extracted in 1945 because of periodontal disease. Dentures were inserted three months after the completion of extractions. The dentures were never comfortable, and the patient stated that he never wore them.

Preliminary impressions were secured with difficulty because of the large tongue. Oversized acrylic trays were constructed. These were muscle trimmed with impression wax, and the final impressions were secured with a free flowing zinc oxide-eugenol paste. The impression wax revealed a close approximation of the anterior borders of both rami to the tuberosities as the mouth opened, reflecting the need for very thin maxillary flanges posteriorly, and affecting the prognosis adversely.

Fig. 7.

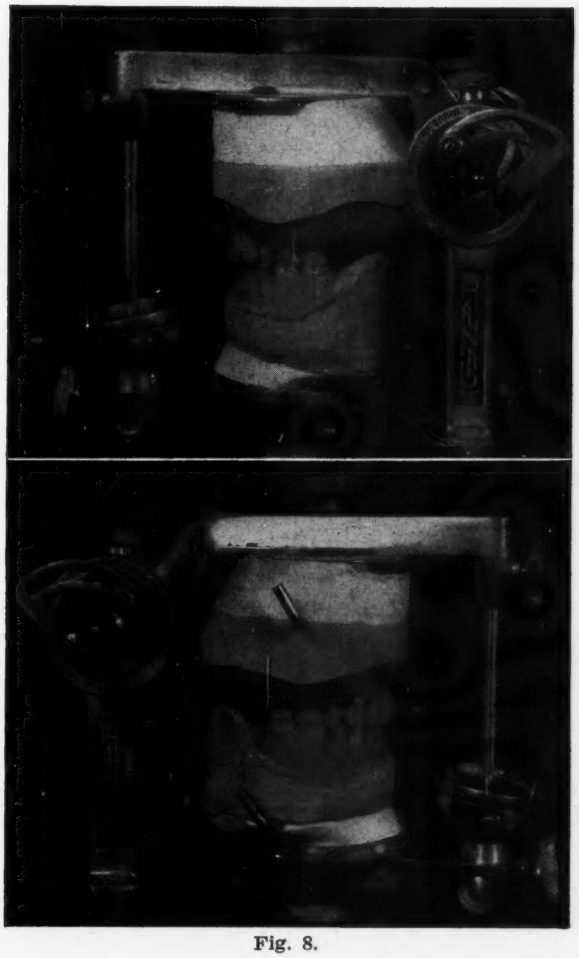

Fig. 8.

Fig. 7.—Lateral views of the processed dentures remounted and with the occlusion equilibrated.
Fig. 8.—Lateral views of the processed dentures remounted and with the occlusion equilibrated.

Baseplates were constructed and stabilized with a lining of self-curing acrylic. These baseplates were then polished as thinly as possible over the tuberosities and retromolar pads. After adjustment of the maxillary occlusion rim to an acceptable high and low lip line, vertical dimension at rest position was determined by usual extraoral procedures. The maxillary cast was related to the articulator by means of a face-bow record. The extreme overdevelopment of the skull is illustrated by the fact that the readings on the calibrated adjustable

arms of the Hanau face-bow were 8.1 on each side. Because the maxillary cast, when attached, was not centered in the articulator, a second face-bow record was made. Inasmuch as a similar deviation was present, it was assumed that the growth of the skull was asymmetric and the record was accepted. Because the thick, bulky tongue precluded the use of intraoral central bearing plates, centric relation was recorded by means of a soft wax registration. At no time was it possible to get the patient to protrude his lower jaw sufficiently to get a wax record suitable for determining the inclination of the condyle paths so the condylar guidances were arbitrarily set at 30 degrees. A wide, short mold was selected for the anterior teeth.

To avoid any possibility of stress over the tuberosities or retromolar pads, the first bicuspids were omitted. Following a try-in, the dentures were processed, and replaced on the articulator to the original mounting by means of split remounting plates. The processing error was corrected, the occlusion was equilibrated after the principles of Schuyler (Figs. 7 and 8), and the dentures were finished, polished, and inserted. Probably because of the long period during which time the patient had been edentulous, he had some initial difficulty closing into centric occlusion, but rather closed in a protruded edge-to-edge relationship. The patient returned twenty-four hours after insertion of the dentures. The primary complaint was some pain and discomfort in the region of the buccal pouch. Visual and digital examination revealed the discomfort to be centered in the soft tissue covering the anterior border of the ramus on the right side. The buccal flanges on both sides were thinned to translucency without reduction of flange height.

The patient stated discomfort was lessened, and he was instructed to try eating the same kinds of foods with the dentures that he had eaten without them.

Three subsequent visits over a two-week period, with minor adjustments, resulted in a reasonably satisfied patient.

The prognosis for this denture patient is guarded. Although the medical service feels the pathosis is static at present, there is no assurance that further deformity of the bony support for the denture-bearing tissues with loss of fit of the dentures will not occur.

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Veterans Administration Hospital
Lyons, N. J.

ACCURATE OCCLUSAL RELATIONS IN PARTIAL DENTURE CONSTRUCTION

L. S. Beckett, M.D.S.(Syd.)

Sydney, Australia

CORRECT CENTRIC and eccentric occlusal relations are just as necessary and important when constructing partial dentures as they are for full dentures. Although these registrations are apparently more easily obtained in partial denture work, a frequent experience is to find that the vertical dimension is greater in the finished dentures than that observed when centric occlusion was recorded. It has then been necessary to correct this by grinding the occlusal surfaces of the artificial teeth, often to such an extent that these surfaces must be reshaped to restore their efficiency.

THE PROBLEM

This puzzling circumstance occurred so persistently as to prompt an investigation in an endeavor to find the cause of the trouble. The various steps from the making of the impression to the insertion of the finished denture were accordingly examined in relation to each other. This did not give a great deal of useful information until it was noticed (while registering centric relation during the construction of a partial lower and full upper denture) that, although the lower occlusion rim and the patient's natural teeth registered perfectly against the full upper occlusion rim, the plaster teeth of the cast failed to touch the upper occlusion rim by nearly one-sixteenth inch (Figs. 1 and 2). The occlusion rims were returned to the mouth, and the patient was instructed to close very slowly. This showed that the compound surface of the lower occlusion rim met the surface of the upper occlusion rim in advance of the natural teeth. As pressure was applied, the occlusion rims displaced the resilient mucosa. This allowed the natural lower teeth to make contact with the full upper occlusion rim. When the occlusion rim was transferred to the unyielding master cast, the vertical dimension was then open to the amount of the tissue displacement by the occlusion rim.

This error was at its maximum because the impressions had been made with a hydrocolloid impression material in order to have an impression and master cast of the teeth at rest. This is of great importance if the finished denture is to be comfortable, and the teeth with which it is in contact are to be free from strain.

A sectional compound impression would displace the tissue on the saddle areas, but would give an impression and cast of the teeth under strain. A compound and hydrocolloid combination impression would give an impression of the teeth at rest, but it is difficult to replace the compound saddle exactly in the position

Received for publication Nov. 2, 1953.

which it occupied when the compound part of the impression was made prior to cutting away the area around the teeth in preparation for the hydrocolloid insert. These types of impressions are not satisfactory because they are unreliable, and because the displacement of the mucosa is not under accurate control.

Fig. 1.

Fig. 2.

Fig. 1.—A centric record of a partial lower against a full upper occlusion rim. Note the failure of the lower second bicuspid to make contact with the facet in the upper occlusion rim when it is replaced on the cast. The bicuspid was in close contact in the mouth when the occlusal surface of the free end of the lower occlusion rim was softened, and the occlusal relations were recorded.

Fig. 2.—The same mounting, but with the distal extension occlusion rim cut away. Note the contact of the second bicuspid with the upper occlusion rim.

REQUIREMENTS

The problem, therefore, resolved itself into finding ways and means of recording centric (and eccentric) occlusal relations that would not cause displacement of the mucous tissues by the occlusion rims during the process. Also, as this error does not occur in all cases, it is desirable that cases should be typed so that preventive measures can be taken if and when required.

REMEDIES

One obvious remedy is to build into the occlusion rim occlusal rests on the abutment teeth of half round stainless steel wire. This would have the effect of using the abutment teeth to absorb the displacing force. In effect, the aim must be to deliver in the finished denture, a denture-to-tooth relationship as originally established during construction between the occlusion rim and the master cast. To be successful, this remedy requires that the wire occlusal rests must touch the teeth of the master cast when the occlusion rim is seated on it.

This procedure will take care of cases in which occlusal rests can be used, but the worst offenders were found to be those with distal extension saddles.

By a process of elimination, so far, it is possible to deal with all cases except those with distal extension saddles, i.e., that group which does not require any occlusion rim to establish a correct relation, and all cases with Class 1 and/or Class 3 saddles,[1] where occlusal or lingual rests can be used at both ends of the saddles.

A solution had to be found for those cases in which one or more distal extension saddles were present, with or without saddles having two abutments. The saddles of the occlusion rims should be made to fit accurately in order to afford

as much resistance as possible between the occlusion rims and the soft tissue surfaces of the saddle area.

The use of an occlusal rest on the abutment at the anterior end of the distal extension saddles would establish control over this end of the saddle, but not the distal end. Even after repeated softening, the wax or compound occlusion rim displaced tissue, and was therefore too unreliable to be considered a satisfactory method. It was finally decided to make the occlusal record in a material of a texture similar to the impression hydrocolloid. Plaster preparations, such as, Truplastic were eventually chosen as satisfactory.

CLASSIFICATION OF OCCLUSAL REGISTRATIONS

A classification of partial denture cases, based on the need for the safe distribution of occlusal stress, has been evolved and used with considerable success, as an aid to denture design.[1] The present problem concerns the *control* of occlusal stress. It has sufficiently similar requirements to justify an attempt to determine the grouping of different cases by the principles underlying the classification.

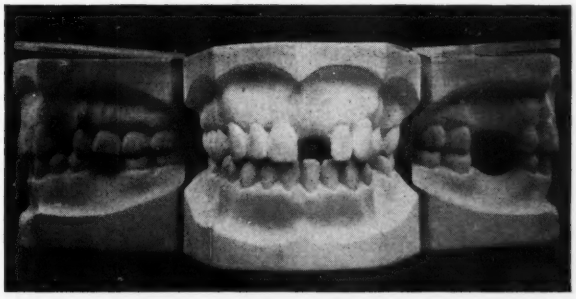

Fig. 3.—*Type A.* Casts with three or more widely spaced occlusal surfaces in normal contact.

The classification is based on the type of tissue used to support the denture.

Class 1 Saddles are tooth borne.

Class 2 Saddles are mucosa borne.

Class 3 Saddles have abutment teeth at each end of the saddle, but there is doubt as to their competence to absorb the additional stress from the saddle. They are problem or overload saddles.

For the purpose of diagnosis, there are four composites of these three basic classes made up of the various combinations of classes within the same denture. These composite classes are not relevant here.

Ultimately it was found that all partial denture occlusal relations belong to one of four types.

Type A—There is sufficient occlusal contact to render the relation of the upper and lower casts so obvious that no occlusion rims are required (Fig. 3).

Type B—There is insufficient occlusal contact to permit placing the casts in definite relationship, and a definite relationship can be established

by using occlusion rim supported in the Class 1 and Class 3 saddle areas by means of occlusal rests, or other support on the teeth (Fig. 4).

Note—The presence of a small Class 2 saddle need not put a case in Type C if the occlusal relation can be registered as previously mentioned without depending upon the Class 2 saddle area.

Type C—There is occlusal contact between some opposing teeth, and/or Class 1 or Class 3 saddles to act as a stop for the purpose of establishing the

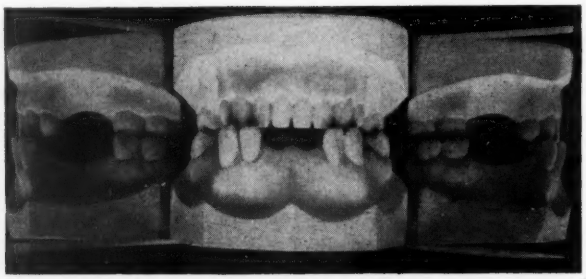

Fig. 4.—*Type B.* Occlusal contact without positive means of determining the relative positions of the maxillary and mandibular casts. The use of upper and/or lower occlusion rims is necessary in this type of registration.

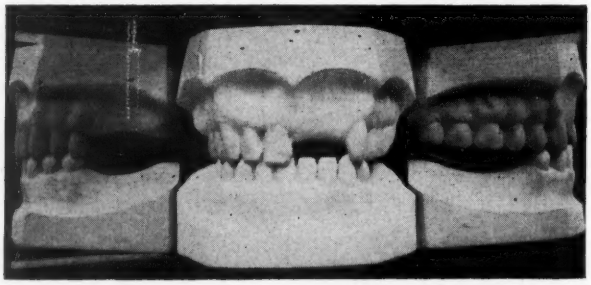

Fig. 5.—*Type C.* Insufficient support for occlusion rims by means of occlusal rests. This situation is usually found in the presence of Class 2 saddles. Truplastic or a similar material is used to record the jaw relations in the Class 2 saddle areas.

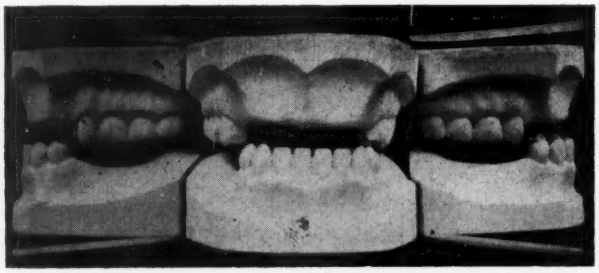

Fig. 6.—*Type D.* There is no occlusal or incisal contact to determine the vertical dimension and act as a stop when the centric occlusal record is made. Stops must be established as near as possible to the abutment teeth. Then proceed as for Type C records.

correct vertical dimension, but this occlusal surface is not sufficient to permit placing the casts in the correct centric relation, and in addition there are one or more Class 2 saddles which must also be used to establish centric and other relations (Fig. 5).

Type D—There is no occlusal contact between opposing teeth, and/or Class 1 or Class 3 saddles to act as a stop for the purpose of establishing the vertical dimension, and there are Class 2 saddles which must be used for the purpose of recording centric and other relations (Fig. 6).

OCCLUSAL RECORDS

Type A.—The procedure to be adopted for Type A cases is self-evident. The casts are fastened together in correct centric occlusion as indicated by the occlusal surfaces of the teeth (Fig. 3). Eccentric relations are seldom necessary, but if required, they can be recorded on tinfoil-wax sandwich check bites. Occasionally, a case will occur in which casts, which should occlude properly as compared to the relations observed in the mouth, will be held out of centric occlusion by one or more teeth. This is due either to the tooth or teeth being displaced under the stress of occlusion but not during the making of the impression, or by the use of impression methods which place pressure on teeth that are slightly mobile, which produces an impression and cast of the teeth in strained positions.

Teeth displaced under occlusal stress will usually (but not always) be anterior teeth. The usual remedy is to adjust the occlusal or incisal surfaces before making the impressions until there is uniform contact and no tooth displacement. When the teeth are displaced during impression making, a different impression material should be selected. It should be one that will record the position of the teeth at rest.

Type B.—In those instances that the vertical dimension must be increased in a Type A case, it then becomes Type B. The occlusion is registered on occlusion rims supported by occlusal rests or other support on the teeth (Figs. 4 and 7).

There are two variations of this type of record:

(1) Where only one occlusion rim is required to successfully establish centric and, if required, eccentric occlusal relations.

(2) Where both an upper and a lower occlusion rim are required to establish centric relation and, when neceessary, eccentric occlusal relations.

If it is necessary to increase the vertical dimension, this should be established in the region of the center line either by making a compound pad on one or both of the occlusion rims, or by molding a softened but firm piece of compound over the central incisor teeth, and directing the patient to close into it until the desired increase in vertical dimension is obtained (Fig. 7, *S*). It may be necessary to predetermine this distance by attaching study casts to an anatomic articulator with

the aid of check bites made in a fully closed position, and checking the amount of vertical movement of the incisal guide pin during lateral excursions. If the pin rises too abruptly from the incisal guide plate, lengthen the pin until the lateral occlusal positions do not lift the pin when the guide plate is set at an angle of 20 or 30 degrees, as required.

Fig. 7.

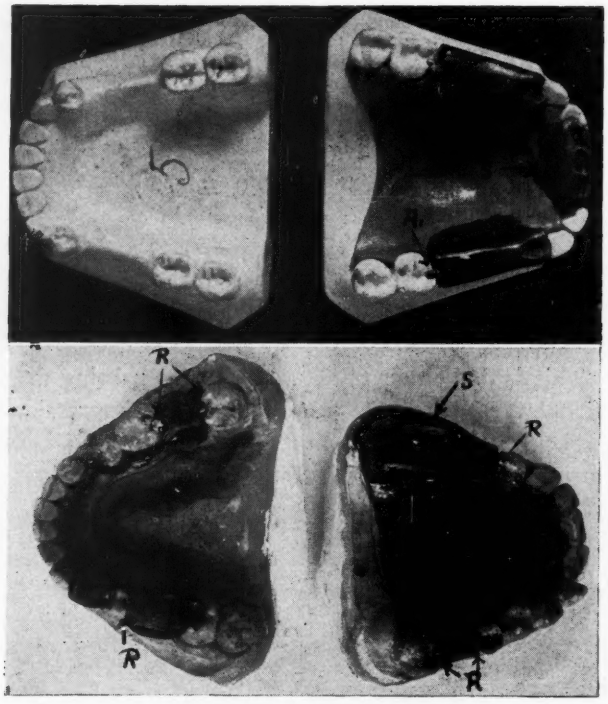

Fig. 8.

Fig. 7.—A *Type B* occlusal record. The occlusion rims for Type B records have occlusal rests *R* and R_1 and support on the lingual surfaces of the anterior teeth to prevent movement of the occlusion rims toward the mucosa with the consequent displacement of the mucosa. When an increase in vertical dimension is required, a compound pad or acrylic stop is used at *S*.

Fig. 8.—A *Type C* occlusal record. The first stage is recorded in modeling compound to obtain a record of all except Class 2 saddles *S*. Then the occlusion rim of each Class 2 saddle is trimmed one-eighth inch short of the opposing teeth or saddle. Note the wire occlusal rests at *R*.

Occlusion rims for this type of case must have accurately placed occlusal rests firmly attached to the bases because the occlusal rests are to transmit the pressure used in establishing the occlusal relation. The record is made by means of the softened compound surface of the occlusion rims (Fig. 7, *RR*). Careful examination of the relative position of the teeth on the upper and lower master casts will determine whether one or two occlusion rims are required and, if only one is necessary, whether it should be used on the upper or the lower cast in order to ensure the maximum accuracy.

Occasionally, the presence of a very extensive anterior (Class 3) saddle of eight or more teeth in length, and involving a long curve between abutments will

have to be treated as a Type C case with a plaster key, because the abutments cannot support the curved saddle.

Type C.—If a Type C case has any Class I or Class 3 saddles, it is usually necessary to proceed as for Type B cases before attempting to record the relations of a Class 2 saddle in plaster (Figs. 5 and 8). Plaster is so soft that the closure must stop on something more resistant in order to maintain control over the vertical dimension. This control or stop is usually by contact of the remaining teeth. This is often supplemented to advantage by blocks in any Class 1 or Class 3 saddle areas. If there is to be an increase in vertical dimension, a pad is used between appropriate opposing teeth, or the blocks in Class 1 and/or Class 3 saddle areas may be used (Fig. 9, *O*).

Fig. 9.

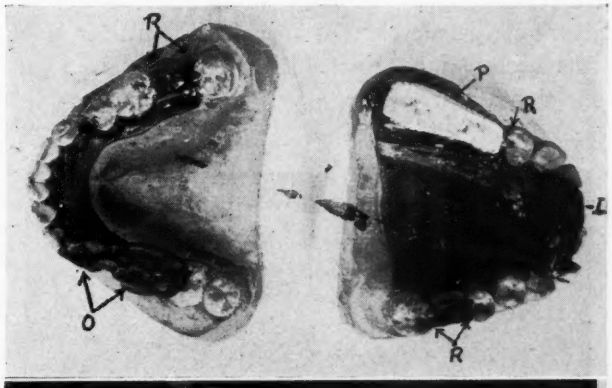

Fig. 10.

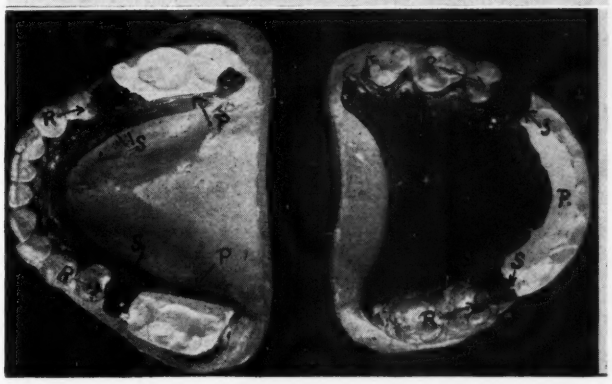

Fig. 9.—A *Type C* occlusal record 2nd Stage. A plaster record is made for the Class 2 saddle. In this case, centric relation has been recorded with an increase in vertical dimension. An anterior compound pad *I* is used to maintain the correct vertical dimension. The plaster key *P* determines the relation of the Class 2 saddle. Note the occlusal rests *R*.

Fig. 10.—A *Type D* occlusal record with four compound stops *S* close to the abutment teeth with occlusal rests *R*. These are used to stop the closure at the correct vertical dimension. Then the plaster keys *P* are made to relate the casts correctly in centric position.

Variations in vertical dimension are determined as suggested for Type B occlusal records (Figs. 7, *S* and 9, *O*).

After recording the occlusion on any Class 1 and Class 3 occlusion rims, the position of the occlusion rims should be inspected in the mouth to make sure that

they have not tilted or moved when this part of the occlusion record was established. Any movement of the occlusion rims at this stage will disturb the accuracy of the final recording in plaster on the Class 2 saddle areas.

After establishing the occlusal relation at the required vertical dimension, as for Type B cases, the Class 2 occlusion rims are trimmed so there is a space of about one-eighth inch between them and the opposing occlusion rim or teeth, and their surfaces are grooved and lubricated (Fig. 8, *S*). Plaster of Paris, mixed to the same consistency as the original impression material, is then placed on the surface of the compound occlusion rim, and the required occlusal position is recorded by directing the patient to close until the teeth and Class 1 and Class 3 occlusion rims meet (Fig. 9, *P*). This position is maintained while the plaster sets. If the plaster is too thick, too much pressure will be exerted on the saddle, and the finished occlusal record will show an increase in its vertical dimension. The most satisfactory consistency is that in which the plaster is just thick enough to stand up on the occlusion rim in sufficient thickness to register the occlusal relation (about one-eighth inch).

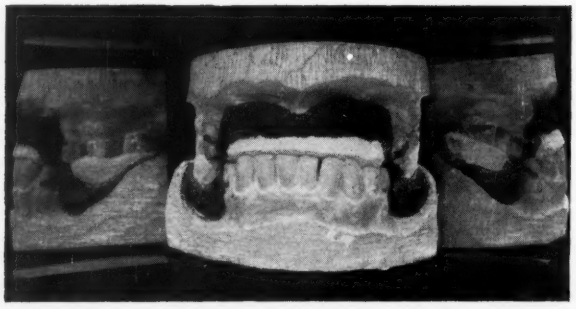

Fig. 11.—A *Type D* occlusal record. The casts, occlusion rims, and plaster keys are assembled. Both the plaster and compound surfaces should fit against the opposing teeth.

Occlusion rims for this type of registration should have occlusal rests fitted to the abutment teeth next to the Class 2 saddles as an added precaution against soft tissue displacement (Figs. 8 and 9, *R*). The occlusion rims must be made with great accuracy so there will be as much tissue contact as possible when they are in the mouth. The whole of the periphery of the occlusion rim must be free of the adjacent muscle attachments.

Type D.—In these cases, there are no positive stops against which the mandible can come to rest (Fig. 6). The accuracy with which the occlusion rims are constructed is even more important in Type D cases than in the previous types. It is usually necessary to burnish thin tinfoil over the tissue surface of the cast, and line the occlusion rim with a zinc oxide-eugenol impression paste. Also, occlusal rests must be fitted to *all* abutment teeth. Those opposing teeth which are nearest to each other when closed should be allowed to close into the occlusal surfaces of the occlusion rims, in order to register the desired vertical dimension (Fig. 10, *S*). By selecting the opposing teeth nearest to each other, the contact pres-

sure is kept as near to the occlusal rests as possible. Thus any tissue displacement, which is unavoidable to some extent, is reduced to a minimum.

The remainder of the surface of the occlusion rim on each mucosa supported saddle is trimmed as described for Type C records, and the occlusal relation is registered in plaster (Fig. 10, *P*). The patient should be instructed to bring the jaws together as gently as possible, consistent with maintaining a steady contact while the plaster sets (Fig. 11).

SUMMARY

1. Occlusal pressure should be transmitted to teeth adjacent to the saddle areas with the aid of occlusal rests in order to eliminate, as far as possible, the variable factor when making occlusal records for partial dentures—soft tissue displacement.

2. When a registration on occlusion rims supported by the teeth is insufficient, and a record must be made on saddles supported by mucosa, the consistency of the medium in which this registration is made should approximate that of the material used in making the impression.

3. Occlusion rims for all types of occlusal relation records should be made of shellac baseplate with modeling compound rims. They should be made as accurately as possible, especially where they make contact with the teeth and stress bearing areas. The occlusion rims must not change their position relative either to the teeth or the casts when they are transferred from the mouth to the casts and vice versa. Wire occlusal rests made of a light gauge half round stainless steel wire should be accurately fitted to the abutment teeth whenever possible. These rests, together with any part of the occlusion rim in contact with the lingual surfaces of the teeth, act as guides for the occlusion rims when they are in the mouth and on the cast. In difficult cases, the occlusion rims should be fitted with the aid of a zinc oxide-eugenol impression paste.

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No. 1 Creston, Aston Gardens
Bellevue Hill
New South Wales
Australia

RELINING REMOVABLE PARTIAL DENTURES FOR FIT AND FUNCTION

VICTOR L. STEFFEL, D.D.S.*

College of Dentistry, Ohio State University, Columbus, Ohio

ALL PROCEDURES in all phases of dentistry may be said to be truly important. It would be difficult to single out any one service as being definitely more beneficial than all others. Nevertheless, it can be stated with certainty that the timely and accurate relining of removable partial dentures constitutes a prosthetic service of inestimable value. This procedure, carried through with precision, accrues to more efficient mastication, to the health of all supporting structures, the teeth, mucous membrane and osseus tissues, and to the correct repositioning of the partial denture. Also, this last advantage re-establishes occlusion with opposing teeth and restores maximum stability to the partial denture within its own supporting arch.

To many who are keen students of dental prosthetics, it is quite disconcerting to learn that many prosthodontists do not reline complete dentures. Relining is considered neither beneficial nor practical because, even in the hands of the most skilled, the entire painstaking and time-consuming operation may result in major errors and discrepancies. It takes only a little thought to render this attitude on the part of some thoroughly understandable. So with reference to complete dentures, the theory of "discarding the old and constructing the new," is largely sound.

Removable partial denture relining, however, presents an entirely different problem. In securing the relining impression of a properly designed partial denture, the appliance, upon each insertion, is steered accurately into place by either clasps or precision attachments. There is, therefore, no chance for the restoration to be misplaced either anteriorly, posteriorly, or laterally. With ordinary caution in carrying out the steps in the procedure, there is no danger of the relining impression recording an eccentric relationship due to the centric occlusion index afforded by the remaining natural teeth. And, because of the piloting provided by the direct retainers along with the interarch relationships presented by the natural tooth contacts or facets, the occlusal plane elevation of the partial denture can readily be re-established at the time of making the corrective impression. There are many guiding and interlocking factors combining to aid us in removable partial denture relining which are entirely lacking in the building of the same type of impression for complete dentures.

Read before the Academy of Denture Prosthetics, Los Angeles, Calif., April 15, 1953.
Read before the Partial Denture Section of the American Dental Association, Cleveland, Ohio, Sept. 30, 1953.
Received for publication Sept. 21, 1953.
*Professor of Prosthetic Dentistry.

OBJECTIVES OF RELINING

In its ultimate attainment, partial denture relining is the means by which the displaceable mucous membrane, osseus structures, natural teeth, occlusal contacts, and the complete removable restoration can be all readjusted and synchronized to best resist and support functional stresses; and further, it is the means by which the components of the temporomandibular joint are restored to and maintained in a harmonious relationship, avoiding in this area displacements, impingements, retrogressive changes, and pain.

Only the correcting of *lower* removable partial dentures by relining will be considered in this treatise. It is, no doubt, within the realm of truth to say that 70 to 80 per cent[1] of all partial dentures made and in use are of the bilateral, distal-extension saddle type, and the great majority of this stated percentage are being worn in the mandibular arch. The lingual bar partial denture, both because of the great numbers in which it is found and because of the unfavorable conditions under which it must function, is the one which most often needs revamping and servicing. Therefore, this article will be devoted to a consideration of that which most needs it—the lower distal extension saddle type of restoration.

Upper partial dentures which have been properly extended for adequate tissue coverage require a minimum of reorienting, if any at all, that might be due to a shift in the positional relationship of the partial denture to the supporting and opposing structures. Physiologic stimulation of the tissues seems to occur as a natural normal sequence in the maxillary arch. Those upper dentures, predominantly of the free-end saddle design, rarely need improving by relining because all biologic and mechanical factors are extremely favorable to this arch, in contrast with the conditions presenting in the mandibular arch. In the upper jaw,[1] the efficient and permanent functioning of the artificial appliance is practically insured by the large tuberosities, broad ridges, and resilient tissues due to the presence of a mucoperiosteum, an abundant blood supply, and the possibility of extensive tissue coverage for stress distribution and support. In the lower arch, in addition to the regrettable fact that all the favorable points previously mentioned are lacking, ridge support is structurely poor and in small quantity, the mucous membrane is relatively thin, and any necessary repair of tissue takes place slowly.

A brief reference to the dental literature will further substantiate the arguments in favor of partial denture relining service as it relates to the supporting tissues; Weinmann and Sicher:[2] "The pressure-bearing bones . . . are reinforced by the production of new bone . . . . The reaction in this case proves the contention that the increase of any physiologic stress in the limits of tolerance acts as a growth stimulus on bone . . . . Growth of bone is stunted under disuse . . . . An excellent object for detailed study of the changes in bone with elimination of function is the jaw. Here, several stages of disuse atrophy can be recognized. The first of these stages is evident in the bone surrounding a

tooth which has lost its antagonists . . . . The supporting bone is greatly reduced . . . . The second stage of disuse atrophy can be observed in the edentulous area after loss of one or several teeth. The changes . . . consist of a regenerative period followed by reconstruction . . . . This process of reconstruction . . . depends upon the presence or absence of functioning teeth. As long as function is maintained in the neighborhood, the spongy bone shows a definite functional arrangement. The leveling of the alveolar process is moderate and the compact lamella at the surface fairly strong. If the loss of teeth is extensive [with no restoration of function], . . . the osteoporosis is much more severe and the loss of bone substance at the alveolar ridge is much greater . . . . The most extensive disuse atrophy of the jaws is found after total or nearly total loss of the teeth. If all the teeth have been lost and no denture is worn [to apply functional stresses], the entire alveolar process gradually is resorbed."

WOLFF'S LAW OF TRANSFORMATION[2]

". . . Functional stresses shape the bone . . . [and] will lead to changes in the form and structure of bones[4] . . . . Lack of function leads to osteoporosis; increased function may lead to the formation of . . . bone . . . . Within the limits of tolerance, an increase of the normal forces of pressure or tension leads to formation of new bone."

"Bone tissue is in continuous flux throughout life. According to the change in the mechanical requirements . . . , an internal reconstruction of bone tissue takes place."

The anatomists and physiologists have not yet successfully explained how mechanical forces stimulate the deposition of bone, and how lack of function brings about bone resorption. Nevertheless, these occurrences now constitute an accepted premise, practical findings have established it as axiomatic. As a result, articles by various writers appear in support of the benefits of relining. Applegate writes:[3] "An impression material is required which will effect partial displacement in the softer areas . . . ; where stress is applied, the fluid content of the subjacent tissues will be slightly displaced. After the load is released, a slight tissue rebound occurs . . . . This physiologic stimulation maintains a healthy condition and counteracts resorptive processes." Girardot says:[4] "The saddles . . . should conform to the functional shape of the tissue, rather than the anatomic shape. This is assured by a special relining technic." Osborne states:[5] "There is no doubt that the dental profession could avoid many prosthetic difficulties if the principles of [partial] denture relining . . . were more universally adopted." A statement made by Roberts[6] is particularly relevant: "Close adaptation to the basal seat contributes to stability. Tissues which . . . are contained by the denture base will resist vertical crushing loads. The degree of the effective resistance is in direct ratio to the amount of containment. Total containment is obviously impossible." Schuyler[7,8] has repeatedly advocated that: ". . . adaptation of saddles to the tissues . . . [is] essential to the health of the supporting tissues . . . ; [this] adaptation of saddles may be secured by relining the finished denture . . . . Adaptation of the saddles to supporting tissue

is an essential to a favorable distribution of functional force . . . ; the value of the tissue support is in relation to the area covered. [This results in] increased firmness of the underlying tissues and the increased density of the supporting bony structure." In 1945, Steffel[1] advanced that: ". . . Relining, though not always necessary, is never undesirable. No [partial] denture base ever fits so well that it cannot be made to fit better by relining." The preceding quotations have been lifted from the dental literature for the purpose of showing the advisability of relining as a health measure and to present the sustaining opinions of some who routinely do it.

TYPES OF PARTIAL DENTURES NEEDING RELINING

In investigating the types of mandibular partial dentures which might present the necessity for relining, we find that they may be classified into three definite types:

Type 1. Those in which occlusion has been lost, but the bases still fit the tissues.

Type 2. Those in which basal contact has been lost, but the occlusion is still perfect.

Type 3. Those in which there is no longer occlusion with the teeth present, nor do the bases fit the tissues.

The first type pertains to those mouth-wrecking, tissue-destroying partial dentures, not even worthy of the name, which most often have no tooth attachments at all, have short and narrow basal seats, and are entirely tissue borne. This type of prosthetic insert rapidly loses contact with the opposing teeth due to traumatic resorption of the alveolar process. The excessive functional stresses interfere with the interplay between the osteoclasts and osteoblasts and throw them out of balance. Ridge resorption results, but not so fast that the tissues run away from the tissue surface of the bases. So the abbreviated bases still continue to fit the disappearing ridges, since the unattached partial denture is free to follow them to destruction. This type of partial denture should be constructed only for temporary purposes, if at all. And, most emphatically, it need not and certainly should not be dignified by a meticulous relining procedure.

If, however, one were to be inadvertently trapped into the unjustified procedure of relining a denture in this first classification, it would be necessary to use a correcting medium with sufficient body and resistance to raise the appliance back into occlusion with its upper opponents. Various modeling compositions, in a range of fusing temperatures, would be best for accomplishing this unwarranted and destructive end.

In the second type fall the tooth-borne partials. These present the fewest problems. Being tooth-borne, a good occlusion is maintained almost indefinitely; similar to a fixed restoration. The fact that the saddles no longer fit the ridges is a matter of simple concern to rectify. Among cases in this category, the resorption has come about as a result of shrinkage following recent extractions and through "disuse atrophy," as contrasted with that due to "overstimulation." It is almost an elementary procedure to fill in the voids between the ridge

tissues and basal seats; the bases are to be restored to again contact the ridges to close the intervening spaces. In securing this simple reline impression, waxes, modeling compositions, plaster, pastes, in fact, any impression substance which will accurately fill the gaps will be adequate, since ridge tissues will not be expected to support the stresses of mastication. This operation constitutes about all the servicing this form of partial denture ever requires.

The third type of relining problem, the one in which there is no longer occlusion of teeth present, nor do the saddles fit the supporting tissues, is the one with which we are most often confronted. It is exemplified by the too-often-neglected bilateral, distal extension species with tooth support mesial to the bases. The

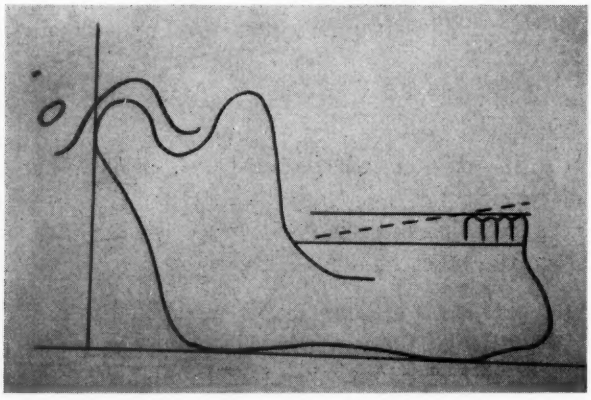

Fig. 1.—A line drawing illustrating how an indirect retainer is raised when base extensions are depressed, and vice versa.

relining procedure for this type of partial denture involves not merely the making of a corrective impression; on the contrary, it generally embodies three objectives:

1. The repositioning of the displaced metal framework.
2. The re-establishing of lost occlusal contacts.
3. The making of an impression which will ensure intimate tissue adaptation of the basal seat.

In most restorations involving a combination of tooth and ridge tissue supports, we are dealing with a loss of synchronized occlusion as a result of partial depression of the distal extensions of the partial denture in addition to the discrepancy in tissue adaptation. Therefore, if the partial denture has three or more tooth contacts (as, for example, the two occlusal stops and the embrasure rest type of indirect retainer), the indirect retainer anteriorly (Fig. 1), will be raised off its seat under the posterior functional loads. And, vice versa, when the indirect retainer is again seated, the distal ends of the bases will raise proportionately with attendant rotation about the fulcrum line.

METHODS OF RELINING

To re-establish stability, two methods of securing a relining impression may be used: (1) the static, or impression paste method; (2) the functional, or semi-functional, method. To permit employment of the first method, the partial denture must have three or more positive seating contacts of its framework against the remaining natural teeth (Fig. 2). The farther apart these contacts are, the better and more stable the tripoding. A restoration which has only the occlusal rests of the two clasps as contacts may tilt anteriorly almost indefinitely when pressure is applied against the lingual bar. With an indirect retainer, the framework is arrested in its downward movement, and immobilized at tooth contact.

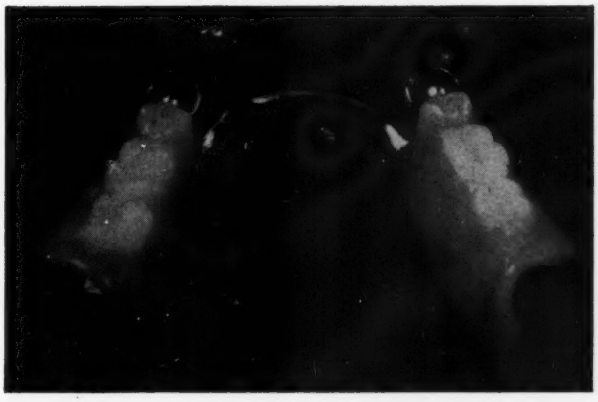

Fig. 2.—A restoration to illustrate that for the repositioning of the metal framework, there must be three (or more) positive contacts against the teeth for tripoding.

STATIC RELINE IMPRESSION

For the static reline impression, very little preparation or modification of the tissue side of the basal seats is required. These surfaces must merely be out of contact with tissues when the stabilizing points are in contact with the teeth, and should be roughened. An impression paste of the operator's choosing (probably one of the zinc oxide-eugenol variety which he likes best to use, or with which he gets best results) is applied in limited abundance, and the partial denture is carried to the mouth where, with the fingers pressing against the anterior framework and with thumbs under the chin, the points of contact are held firmly against the natural teeth. While this is being done, no attention is directed to the distal extensions. The paste-type of static impression literally makes itself as it fills the spaces and flows between the slightly upraised bases and the undisturbed ridge tissues. The resulting imprint records the tissues without distortion. When the impression paste has hardened, the denture is removed, the finlike excesses are eliminated, and the reline impression portion of the denture is converted to plastic in the usual manner by meticulous flasking. If the partial denture is an all-metal type, the reline material is replaced by plastic which

is mechanically locked to the base, or by a metal casting of the same proportions. When the relined denture, now ready for service again, is seated back to place, the metal framework will be accurately reoriented with reference to the natural teeth at the same time as there occurs intimate relationship of the basal seats to the ridge tissues. The occlusion, however, will be heavy, the degree of occlusal disparity depending upon the distance the extensions had raised when pressure was applied anteriorly in the impression making. This interfering occlusion is now reduced only to the level of anticipated tolerance, and the teeth coordinated with their opponents by grinding, all correcting being done on the lower artificial teeth if the denture is opposed by natural one; on both upper and lower teeth if both dentures are artificial. The artificial occlusal contacts should be left "heavy" to allow for estimated reintrusion of natural teeth partially extruded by thickening of the periodontal fibers or for the reseating of an upper denture partially displaced by congested subjacent tissues, and to correct to a certain extent the strained relationship of the temporomandibular joint components.

The method of relining just described, in which there is no displacement of tissues, can be used to secure accurate results only when the design of the denture makes framework stabilization possible (Fig. 2). This fact seems so apparent as not to require further elaboration.

For most relining problems, then, the method of choice is the second, a method which can be feasibly used with any type of denture design, one which enables us to distribute additional stress loads against the slopes of the ridges, and which makes possible the molding of functional saddle borders.

FUNCTIONAL RELINING IMPRESSION

If the partial denture has only the two clasps with no indirect retainer(s), an effort should be made to refine the occlusion before going forward with the relining impressions, which step-by-step procedure will be carried out in the same manner whether or not an indirect retainer is present. If there is an indirect retainer, or additional points of contact of the framework to make tripoding or stabilization possible, in the technique about to be described, it is preferred to reharmonize the positional relationship of the partial denture to teeth and tissues first, and to correct the occlusion first also, before proceeding with the reline impression. To do this, the technical procedure is as follows: Low-fusing modeling composition is placed in excess on the distal one-third to one-half of the tissue surface of the bases (this amount is sufficient for the purpose intended and in convenient location for subsequent removal). The denture is now mass heated in the 140° F. water, quickly carried to the patient's mouth while the impression material is still readily moldable, and seated with firm pressure against only the framework. The material at the distal ends of the bases (Fig. 3) will have contacted the tissues and hardened so that the appliance is now reoriented in relation to its own arch, but out of harmony with the opposing arch. With the modeling composition for support distally, and accurate metal-to-tooth support anteriorly, the partial denture is stabilized and positioned, and the occlusion can now be altered and balanced in accordance with our judgment for this specific location.

After the occlusion has been corrected with the denture being supported at its proper relative elevation, the impression substance which has now served its purpose is removed, undercuts are eliminated from the base, and some base material is cut away from the tissue surfaces and from the peripheries of the basal seats (Fig. 4) to make more room for, and provide better workability of, the impression materials.

Fig. 3.

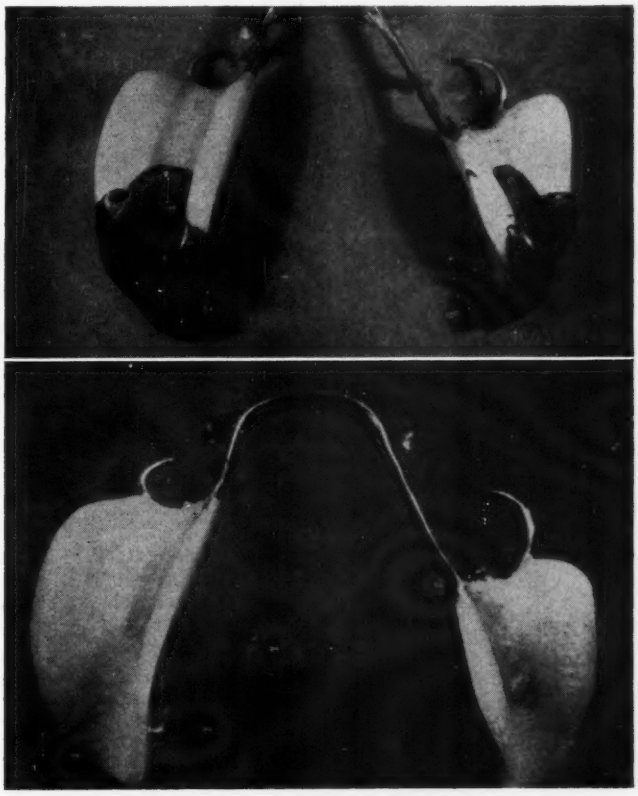

Fig. 4.

Fig. 3.—Modeling composition placed so as to support the distal extensions during the correction of occlusion.

Fig. 4.—The ridge surfaces of the bases prepared to receive the excess of modeling composition.

An excess amount of low-fusing modeling composition (low-fusing to prevent overdisplacement of tissues) is now applied to the bases. Excess is used so that there will always be some present wherever needed. The appliance is mass heated in the water bath and inserted part way toward the tissues but not seated. The patient is not allowed to close for contact. Seating all the way at the first insertion might result in too-severe pressures against supporting tissues, flowing of the moldable materials into the direct retainers, and the lack of occlusal contacts in the finished denture due to overclosure. Usually about four mass heatings and insertions, progressively, are necessary before allowing the patient to close natural teeth to light centric occlusal contacts. For final closure,

the patient should be instructed to proceed just to the point of faint facet-to-facet or interdigitative contact, not asked to close with great force. Doing so might result in an upward mandibular displacement. At this juncture, the bases will be at their correct vertical position, occlusion will be re-established, and because correct occlusal contacts were provided beforehand, the metal work will have accurate adaptation to the natural teeth. Since modeling compositions are always under the operator's control, he can make them do what is required for any specific case; and since they do not soften again at mouth temperatures, there is no danger of his losing subsequently the corrections which he has so painstakingly made.

Fig. 5.

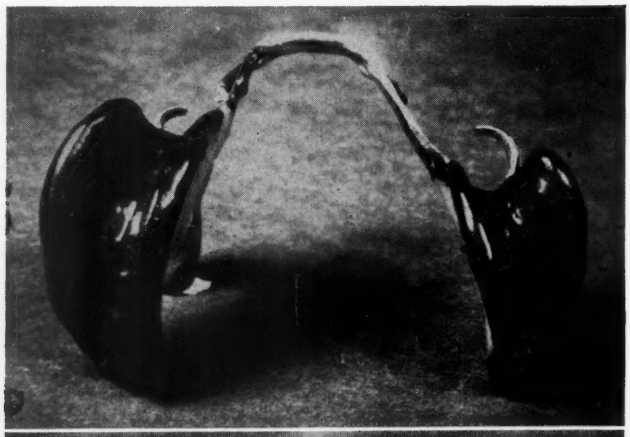

Fig. 6.

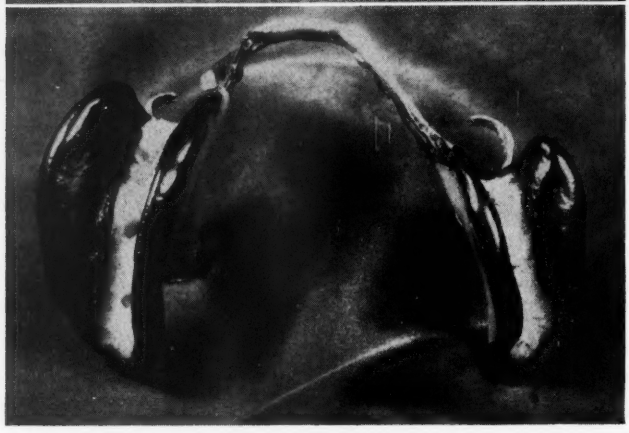

Fig. 5.—The smooth, accurate, muscle-trimmed impression in modeling composition.
Fig. 6.—Bases prepared for the application of impression wax (Iowa Formula).

The border limits are now formed by heating short sections with the torch, then manipulating the cheeks and lips for border outline.

The reline impression (Fig. 5), at this point, *looks* acceptable, with adequate tissue coverage, rounded smooth borders, smooth impression surfaces, and a stabilized, properly repositioned composite partial denture. However, the

borders are really not physiologically trimmed, and as recorded, there will be small inaccuracies in surface detail, excessive stress against the crest of the ridge, and *probably* against the mylohyoid ridge.

Impression substance, and even base material if necessary, is now removed all along the crest of the ridge, and usually along the mylohyoid ridge. Also, if the distal extensions are long, escape holes are bored completely through the base material at these areas requiring relief (Fig. 6); if they are short, their open ends provide sufficient escape ways. *No* impression bulk is removed along the normal slopes of the ridges.

Impression wax (Iowa) is now painted over the entire impression surface, the partial denture is inserted, and the patient instructed to gradually force it to place, then to continue with the functional movements of chewing. In contrast to modeling composition, the wax must always be well chilled before removal for examination. After a short period in the mouth, five minutes for example, excesses of wax should be removed and the restoration reinserted (with wax additions, if necessary). The patient is again instructed to go through the functional movements of chewing, together with facial and oral gymnastics, for about ten minutes. The wax flows so readily that there is no danger of its remaining on any surface where its contour will not be tolerated later. Limited movement of the base extensions under the functional stresses will mold the soft wax for relief of vulnerable areas. Also, in the completed restoration, the slight movement allowed by the passive retainers will preclude the possibility of tissue strangulation.

This final step in the reline impression (the relieving of areas and the addition of wax) does not change the previously re-established position of the partial denture in the arch, but merely refines the impression, and specializes the fit with reference to the different types of supporting tissues. Obviously, at this point, the impression (Fig. 7) is ready for accurate conversion into a permanent material as it presents: (1) A surface which is absolutely smooth and tissue adapted. The wax corrects any small surface discrepancies. (2) A surface outline which will place additional stresses on tissues which can tolerate them, giving relief to others. The rationale of this is clearly understood. (3) Borders (Fig. 8) which have a functional outline molded by physiologic muscular action and not by excessive manual manipulation.

COMPARISON OF METHODS

In evaluating the two methods, it seems clear that this second type of reline impression is "one made to order." Being under the control of the operator, it can be built to best utilize those tissues which must give support. It is a therapeutic measure, and although no thinking operator would advocate shoving tissues around in impression making to the extent of seriously displacing them, nevertheless, the second type of reline impression makes possible a closer adaptation of bases to tissues, more extensive tissue coverage, and carefully limited but fully extended border outlines for greater containment of tissues, all leading to enhanced stability over a longer period of time. This is because all stresses are within the limits of tolerance. The subsequent stimulation of tissues should then

result in a thickening of the cortical layer of bone and in the proliferation of soft tissue cells. As noted previously, the corrected partial denture, upon reinsertion, should present and be left with slightly premature occlusal contacts to allow for the various physiologic tissue adaptations.

Fig. 7.

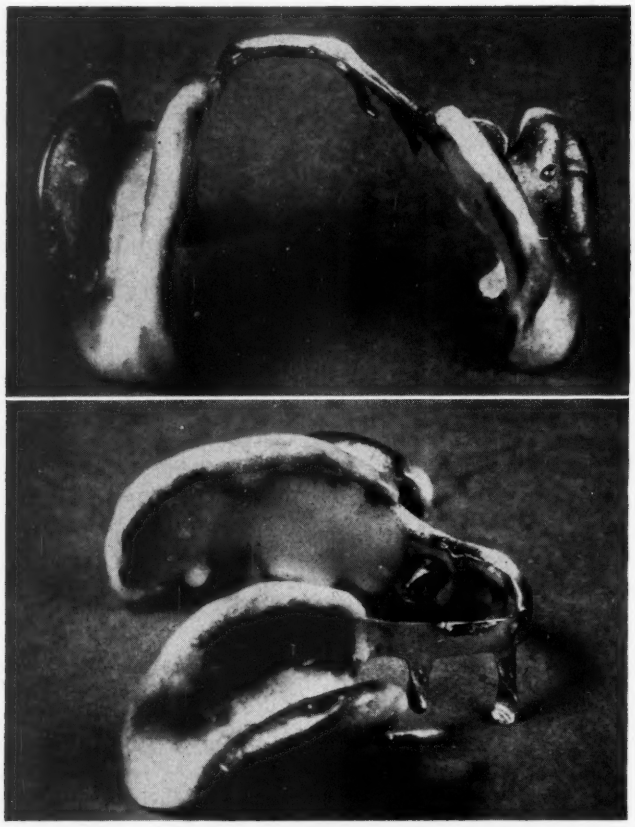

Fig. 8.

Fig. 7.—The finished impression made of modeling composition and wax. Note the escape of wax through holes in the denture bases.

Fig. 8.—The finished impression. Note the well-rounded borders.

The static type of reline impression is probably the one of choice for partial dentures resting on low flat ridges with soft, flabby, unfirm, movable tissues which, at best, are incapable of very satisfactory functional support. This form of relining procedure, due to lack of containment, does not provide the degree of stability to offset either vertical or horizontal stresses, nor is it as efficient for maintaining the partial denture in a correct functional position over a period of years as is the modeling composition-wax method.*

*Regardless of whether the denture bases present the anatomic or functional form of the ridge tissues, it is the author's conviction that, in some cases, a small measure of the maintenance of an unbroken occlusal plane indefinitely is effected by a *very slight* physiologic intrusion[9] of the abutment teeth over a long period of intermittent stress application.

RELINES WITH SELF-CURING RESINS

Only the routine, laboratory-processed type of reline has been considered in this treatise. The method of relining using the self-curing activated resins, while constituting an excellent emergency procedure, serves mostly as a stopgap until such time as a corrective impression can be processed into a homogeneous mass. Although the self-curing reline has the advantage of precluding the possibility of the accurate impression being ruined by a faulty laboratory operation, it does not afford the same opportunity for precise muscle trim, uniform density of plastic bulk, unbroken color, excellent appearance, and refinement of finish as does the processed one.

OTHER CONSIDERATIONS

In many instances, free-end extension restorations seem to maintain excellent occlusal contact almost indefinitely. Is this because of the relining service, is it due to bone apposition and cell multiplication, can it be attributed to the partial extrusion of opposing teeth from thickening of the periodontal structures, does it result from the displacement downward of the upper denture from fluid congestion of the subjacent tissues in dysfunction, or is it because of slight mandibular displacement by the force of the muscles of mastication? The author is advancing the theory that, in addition to the important parts played by the first four, muscle strength and action play an important part in perpetuating good occlusion by changing the relationship between the condyles and the articular slopes under hard stresses.

Craddock[10] recently made an extensive study of many temporomandibular joints by means of roentgenograms. He found that the space occupied by the interarticular soft tissues (Fig. 9) averages 3 mm. in width when measured directly above the condyle. The smallest dimension of the interarticular space averages 2 mm. and is found directly opposite the articulate slope. Posteriorly the space is constantly more uniform and intermediate in width, averaging 2.5 mm. Within limits, Craddock found the condyles to exist seemingly normally in a great variety of locations within their fossae.

The articular slope is said to be the main pressure-bearing region of the joint. Nothing can be found in the dental literature to refute this statement. However, owing to the vast existence of normal variations, it is impossible to define exactly the place on the articular slope with which the condyle is normally in most intimate relation. Also, a definite statement as to the exact normal relation of the other functioning parts cannot be made due to the fact that the joint is adaptable and flexible and presents a wide latitude of movement. To yet further complicate the picture, a condyle may be large, its fossa shallow; or, it may be small and its fossa deep, which would present an articular surface steeply inclined. Problem: state the normal relationships.

As a result of these findings, we cannot determine definitely radiographically whether or not a condyle is in a more intimate relationship with an articular slope than it formerly was. We can merely find that one is a more or less intimate relationship than another or others. Nevertheless, taking into consideration

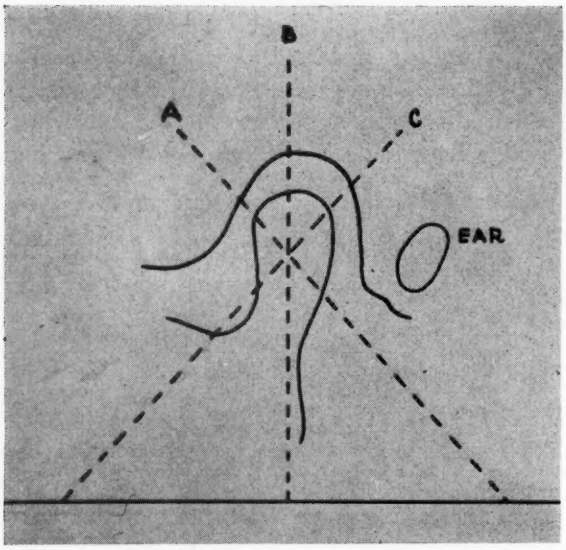

Fig. 9.—Interarticular soft tissue averages 2 mm. through *A*, 3 mm. through *B*, 2.5 mm. through *C*. (Courtesy F. W. Craddock.)

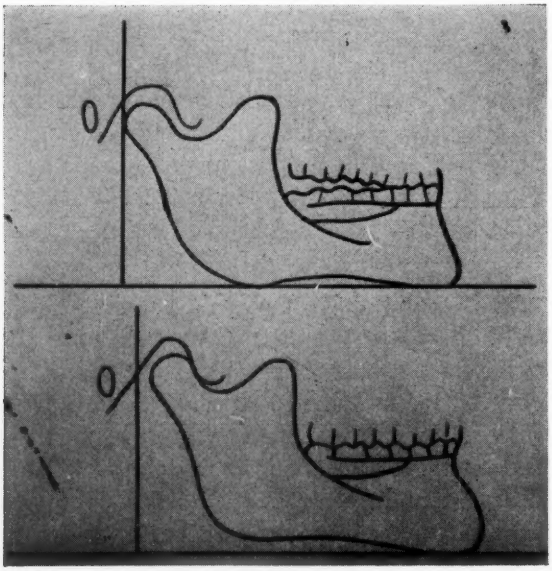

Fig. 10.—Schematic drawing to show the more intimate relationship of the condyle with the articular slope of the glenoid fossa which results from muscular pull after the loss of occlusion distally.

the flexibility of the temporomandibular joint, it certainly is reasonable to assume that since there is a general forward and upward direction of muscular forces on the joint and because upward movement of the mandible is definitely limited anteriorly by the contacting remaining natural teeth, and due to the fact that the histologic structure of the meniscus allows slight upward displacement of the condyles, we may safely conclude that some of the maintenance of occlusal contacts, distally, is effected by the assumption of a more intimate relationship, upward and forward, of the condyles with the articular slopes (Fig. 10). This is just another of nature's many adaptations.

SELECTION OF THE PROCEDURE

On the technical side, the wise and skilled operator is the one who, in his determination to do what is best for the patient, and in his application of good judgment, selects and is able to use the procedure for relining which best applies to the problem at hand and to the structures involved. A qualified expert is distinguished not only by an accumulation of information, but more particularly by his ability to interpolate such information into practice. This statement is admirably supported and best clarified by two scholarly quotations: Girardot,[4] "The problems . . . have ceased to be strictly mechanical and are subordinated to the biologic. The biologic concept of the effect of pressure and movement on living tissue, and the ability of the tissue to accept it, should motivate and direct every application we make of mechanical principles." Pendleton,[11] "Materials and methods avail but little when the structural characteristics of the tissues are ignored. The biologic factors . . . are the directing influence or controls that determine the virtue of the procedures employed in clinical practice."

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College of Dentistry
Ohio State University
Columbus 10, Ohio

COMBINATION GOLD AND ACRYLIC RESTORATIONS

MORTIMER C. DAVIS, D.D.S., AND GEORGE KLEIN

Jersey City, N.J., and Flushing, N.Y.

SINCE THE INTRODUCTION of methyl methacrylate resins some sixteen years ago, both materials and techniques for making gold crowns with acrylic veneers have been greatly improved. The negligible percentage of failures is attributable to faulty techniques or to indiscriminate use of the restoration.

INDICATIONS FOR ACRYLIC VENEERS

Acrylic veneers are indicated: (1) for abutments in fixed bridgework, to house precision attachments, to support various types of clasps; (2) in cases where the protection of the veneer by gold must be the minimal thickness because of the relation of the opposing teeth; (3) on rotated, tipped, and malformed teeth (Fig. 1); (4) for pulpless and crownless teeth in conjunction with gold posts; (5) where only the minimum tooth structure can be removed, or where shoulders are contraindicated, as in fractured incisors in the young patient, and periodontally involved teeth with increased clinical crown length; (6) in multiple abutment restorations. Limited interproximal spaces must provide for adequately strong joints and hygienically proper embrasures.

ADVANTAGES OF ACRYLIC VENEERS OVER PORCELAIN VENEERS

(1) The natural tooth anatomy with unusual contours can be more easily attained with acrylic veneers than with porcelain veneers. (2) Only minimum conventional laboratory equipment is needed in the manipulation and repair of acrylic veneers. (3) The acrylic veneer lends itself to unlimited schemes in shading and staining in the hands of skillful technicians, while porcelain requires the skill of ceramists. This precludes the use of porcelain in the average dental office. (4) The esthetic appearance of acrylic veneers can equal, and in some cases surpass that of porcelain. (5) The gingival fit of the casting is superior to porcelain. The internal dimension of the porcelain jacket is increased because it must be constructed on platinum foil, which is later removed.

SALIENT FACTORS IN VENEER CONSTRUCTION

1. Shoulder preparations on the labial or buccal margins which disappear in the proximal margins are desirable in teeth of normal crown length. Vertical stresses are borne better with shoulders, and the increased depth at the gingival margin assists shade fidelity, translucency, and a lifelike appearance.

Received for publication Aug. 15, 1953. Revised by the authors Jan. 18, 1954.

2. A gold collar provides a better fit for the crown at the labiogingival margin. Finishing acrylic to a butt joint with the tooth shoulder is dangerous because of the possibility of dimensional changes in the acrylic. Fine collars of gold extended slightly below the free margin of the gingiva can satisfy esthetics without sacrificing strength.

3. The acrylic veneer should always be boxed in and retained in the gold with auxiliary retentive devices (loops, mesh, serrations, etc.) (Fig. 2). It is necessary to lock the acrylic into the gold mechanically because of its tendency toward dimensional change; otherwise seepage will occur with an attendant discoloration of the facing.

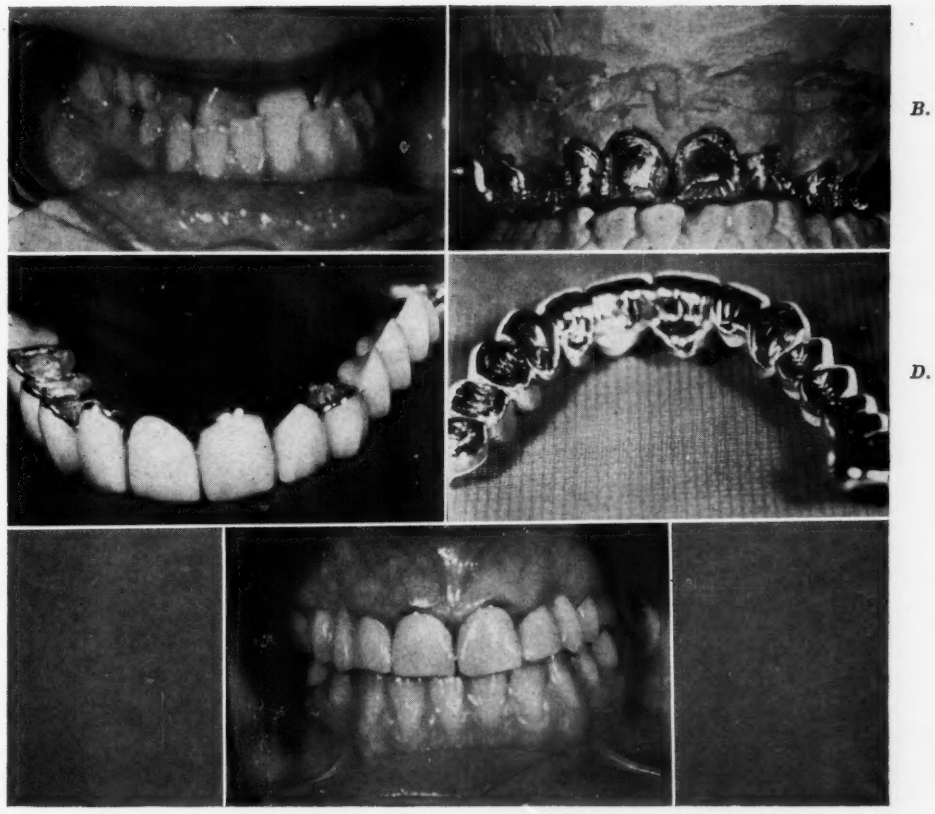


Fig. 1.—A restoration with acrylic veneers on gold crowns and combination gold and acrylic pontics.

4. Proximal contacts should be of gold to prevent wear of the contact area.

5. Veneer windows should be receded so that esthetics are satisfied.

6. Electroplated dies are preferred when the indirect method of construction is used. The stems of the dies can be poured in fast-setting acrylic, which is strong and easy to handle. Acrylic facings can be cured upon these dies. Dowel and precision dowel pins are helpful adjuncts where the cast is to accommodate several dies next to one another.

7. The thickness of the gold on buccal cusps of lower posterior teeth should be increased. These surfaces receive the full occlusal stress and wear. It is not necessary to thicken the buccal cusps of upper veneer restorations because only eccentric contacts are made on these cusps.

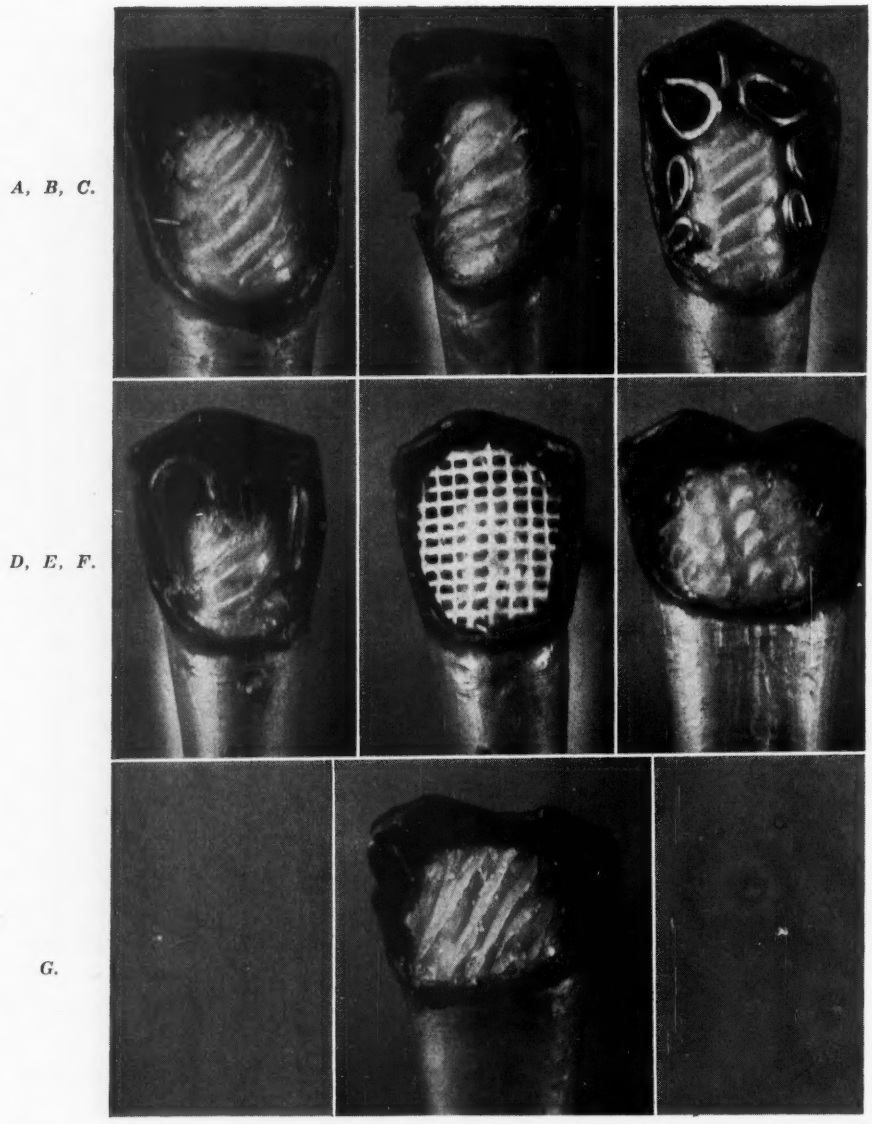


Fig. 2.—Various forms of retention used in veneer crown windows. *A*, Nylon bristles. *B*, Dovetails. *C*, Wire loops. *D*, Wax ear loops. *E*, Mesh. *F*, Wax stubs. *G*, Serrations.

BRIDGE SKELETONS

A complete revolution of concepts has come about in bridgework in a short time. Gone are the two-surface inlays for abutments; so are the one-abutment winged bridges. Two-piece crowns and shell crowns are becoming obsolete in modern dentistry. The three-quarter cast crown appears as an evolutionary method to achieve good fit and superior esthetics, but its permanency as a bridge abutment is doubtful. Today, full-cast crowns with acrylic veneers, used as abutments, have become the restorations of choice because of their strength, immunizing qualities, conservation of tooth structure, and esthetics.

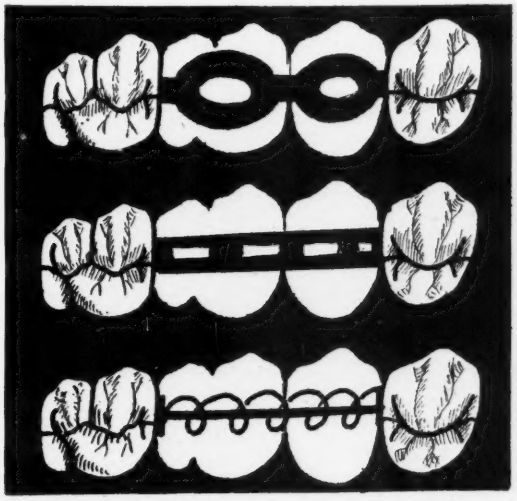


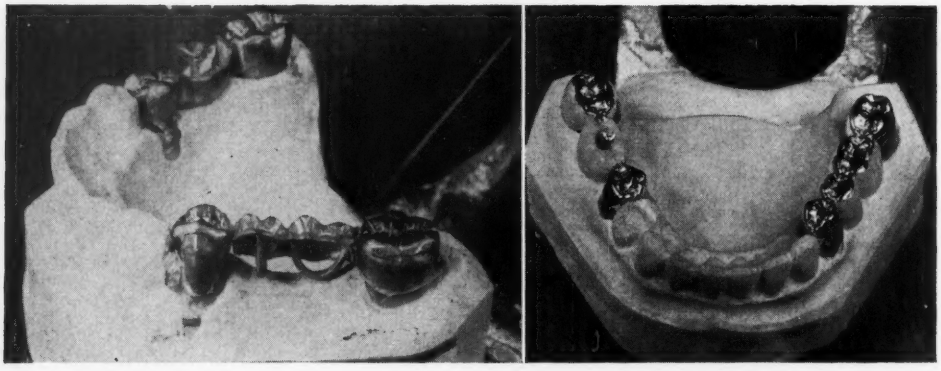
Fig. 3.—Types of reinforcing trusses used to retain acrylic. These bridges failed invariably because the acrylic would both wear and come loose from the trusses.

In bridge pontics too, the change from soldered to cast, from porcelain to acrylic has been phenomenal. The applicability of acrylic bridges is more extensive than that of porcelain, since wherever porcelain bridges are contraindicated, acrylic bridges may not be necessarily. Yet, acrylic bridges are very similar in construction to the porcelain restorations, and they have many features in common. For instance, in baked porcelain bridge construction, iridioplatinum reinforcing trusses are used, and these are usable in acrylic bridges, as are other types of retainers. However, in the construction of retainers for acrylic bridges, a type "C" gold alloy is adequate. Resistance to high temperatures is not a requirement of the metal. The acrylic interchangeable facings, the pontics, and the tube-tooth-type bridges appear practically the same as their predecessors in porcelain, except for the design of the retentions. As can be seen from the illustrations, the resemblance may be close in some cases and quite different in others (Figs. 3-6).

TYPES OF BRIDGES

All-Acrylic Bridge.—No metal skeleton is used in its construction. This type of restoration is ideal for temporary replacements and should be limited to this use as it cannot withstand normal stresses for any long period of time. Variations are hygienic embrasures is difficult.

Reinforced Acrylic Bridge.—This type of bridge may have gold thimbles, inlays, or crowns for abutments which are connected with a metal truss of varying design. These trusses can be of wrought or cast metals such as steel, iridioplatinum, or of a good quality of hard gold. Their shapes sometimes vary from the types used in baked porcelain bridges, to more complicated designs. In all cases, metal designs are constructed so as to prevent the displacement of the acrylic pontics to be processed upon them by vertical, horizontal, or rotary stresses. This type of bridge has been used extensively in the past, but it has several faults. The acrylic can fracture away from the metal structure, and occlusal wear can cause its failure. It is noted as part of the evolution of its more modern counterparts. (Fig. 3).



A. *B.*

Fig. 4.—*A,* Other variations used for the retention of acrylic. The right side has an occlusal stop in gold, while the left side is of the conventional type. Occlusal stops do not provide sufficient protection for the cusps and fossae, and do not prevent occlusal wear of the unprotected acrylic. *B,* The completed restorations.

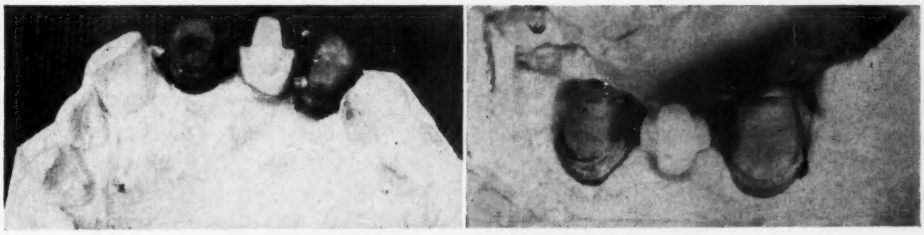
Coping Bridges.—There is only one real advantage that this type of bridge offers. It is the replaceability of the individual jackets in case of fracture. However, with the advent of the cold curing acrylics, this is not of major importance. The thimble or coping bridge is a distinct improvement over the Swann-type porcelain bridge. It offers good esthetics and strength when it is properly constructed, although the embrasures are necessarily small. When abutments for this type of bridge are also of the coping type, no gold need be evident on any surface of the restoration. However, the use of gold copings as abutments either with acrylic or porcelain results in two undesirable features—the necessary solder joint adjacent to coping pontics impairs the strength of the jacket, and the creation of hygienic embrasures is difficult.

Acrylic Facings.—These are used mostly on anterior replacements. They can be veneer-type pontics with the gold tissue contact scooped out to form a hollow

shell, or they may be used as the interchangeable type of facing with the same or modified retentions. An alternative for anterior replacements is a 24 gauge thick gold lingual surface, extended from the cingulum to the incisal third of the tooth with retention loops for attaching the facings.

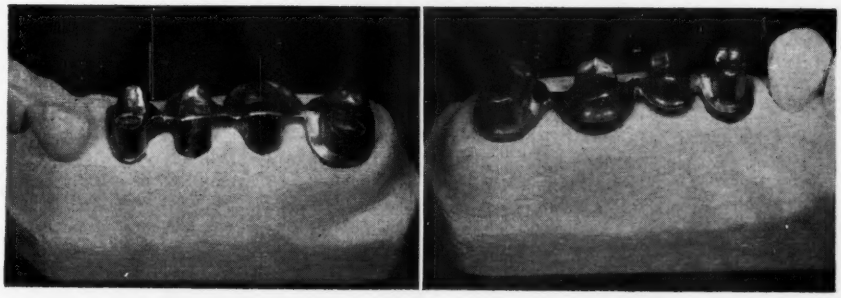
The use of unprotected acrylic on the incisal edge of the tooth for purposes of improving esthetics is hazardous. The difference in light transmission between the protected and unprotected acrylic creates much shade differential. The unprotected portion may also fracture and cause unnecessary trouble.

Acrylic Tube Teeth.—While this type of pontic is seemingly versatile in its use, it has an inherent deficiency in attritional wear. Acrylic must be protected in the posterior part of the mouth with gold occlusal surfaces. The buccal cusps of lower teeth and the lingual cusps of upper teeth in cases with normal occlusal relations should have the protection of a good thickness of hard gold (Fig. 5).



A. *B.*

Fig. 5.—Wax-up of an anterior coping bridge using a prefabricated coping for the pontic.



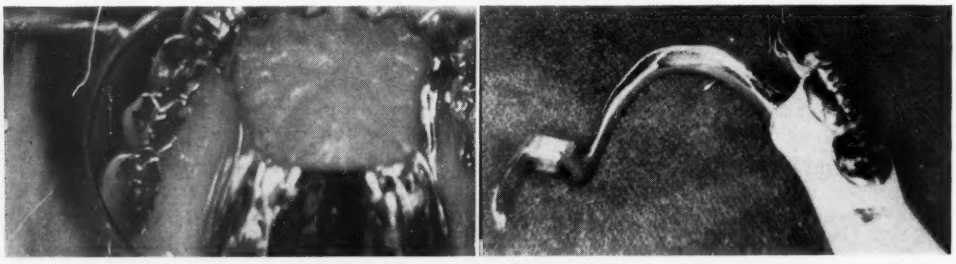
A. *B.*

Fig. 6.—Gold copings for a posterior bridge.

When employing acrylic teeth for partial denture construction, the occlusal surfaces of the acrylic teeth should be protected by cast gold cusps to eliminate the wear. These cusps can be fabricated and the acrylic processed under them, or parallel post holes can be prepared in the manufactured teeth after the saddles are processed; then the occlusal forms can be worked out in inlay wax, and cast and cemented into the acrylic teeth (Fig. 7).

Acrylic Pontics With Gold.—This type of restoration has a gold occlusal surface extending lingually. The gold may be extended for tissue contact, or acrylic may be processed on the skeleton where it will be in direct contact with the tissues.

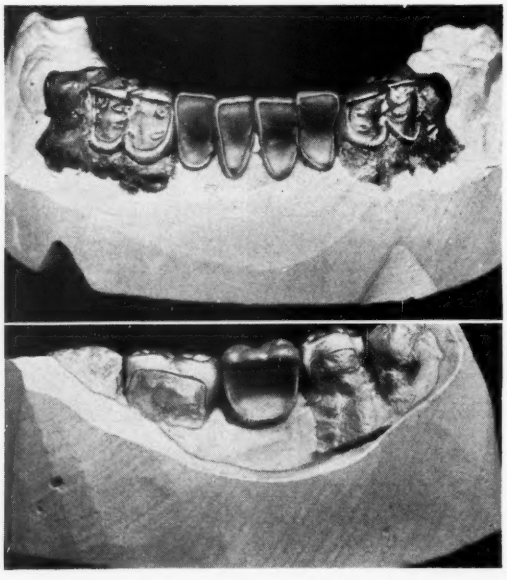
It makes an ideal bridge restoration, being both sturdy and hygienic. Abutments can be cast together or separately. When a soldering operation is used, the joints are placed where nature intended interproximal contacts to be, thus they can be strong and still permit sufficient embrasures to satisfy hygienic requirements. The gold occlusal lingual surfaces form a light, but strong frame that occlusal stresses cannot overcome. Acrylic tissue contact assures a most accurate adaptation to the tissue.



A. *B.*

Fig. 7.—Cast gold occlusal surfaces are used to protect acrylic pontics from wear in these upper and lower precision attachment partial dentures.

A.



B.

Fig. 8.—Prefabricated forms used for pontic construction. Additional retention may be waxed in. The use of this type of pontic is limited because the space must coincide with the width of the pontic.

Reports in the literature and clinical evidence seem to substantiate the belief that acrylic resin is biologically compatible to the oral tissues. How else would we account for similar tolerance where acrylic resins are used for surgical sutures, artificial eyes, etc.? A review of the literature notes an almost complete absence

of adverse reports. The cases where there is evidence of tissue irritation under and around pontics where acrylic is used can be traced to faulty technique, e.g., scraping of casts, lack of proper embrasures, failure to polish the material to a high luster, poor mixing and packing techniques, and the use of inferior products.

Prefabricated Pontics.—With the increasing popularity of acrylics, a number of manufacturers made new developments. Prefabricated pontics made of wax, plastic, and of precast gold are intended to cut down the operating time and thus simplify the procedure. The space being filled, however, must coincide with stock sizes in order for these prefabricated pontics to be useful (Fig. 8).

ACRYLICS FOR JACKETS, COPINGS, AND BRIDGES

When the gold construction of the veneer crown, or bridge is satisfactory, wax-up and processing follows. There are many methods, techniques, and claims for a "sure-fire" way of obtaining any shade. Unfortunately, experience has shown this to be untrue. Let us try to reason on scientifically proved ground that can be used as a common denominator in pursuit of satisfactory shade matching. This is where "common sense is nature's gift, but reason is an art."

When acrylic is processed over gold, and especially if it is being matched with other natural teeth, the first premise we must make is that it is impossible to duplicate the shade. The metal protection creates a different set of refractory factors. What we are really doing is creating an illusion of color fidelity. The best we can hope for is that the illusion shall be complete as far as the patient, friends, and family are concerned.

We must first understand that color is due to the reflection of certain rays of the spectrum, the unabsorbed rays being transmitted to the eyes where they occasion the sense of color. Color is, therefore, not a subjective quality inherent in an object. It is rather the response of vision to a wave length of light. Various objects differ in both texture and composition to such a degree that they absorb certain light rays and reject others, producing different light sensations. In view of the foregoing, it is reasonable to state that in veneer crowns, there are many factors which produce the final shades. They include the size and depth of the veneer window, texture of the gold surface, contour of the tooth, the background, the color of the gold, and the types of retention used.

Processing acrylic on gold without masking it results in a lifeless-looking grayish veneer. While the reflection of the metallic background cannot be completely eliminated, it can be influenced. Toward this end, we can use three methods: (1) flash gold-plating; (2) masking out with opaques; (3) combination of the two (Fig. 4).

FLASH GOLD-PLATING

Unlike gold alloys, flash gold-plating with pure gold brings about a reflection of pink or yellow background. These hues are desirable in most shades, as pink and yellow are the most luminous colors.

The thickness of the plating can further influence the shade. With a heavier plating, we gain a pinkish or reddish hue, while a moderate amount will result in a yellowish background. Therefore, when plating is done on veneer crowns, its

effect and influence should be considered, and its thickness determined accordingly. Gold-plating also brings about a uniform color where the retention is of different colors than the gold alloy in which the crown is cast, i.e., zephyr wire, iridium wire loops, etc.

MASKING WITH OPAQUES

While gold-plating is rapidly gaining popularity, the masking method with paint-on opaques is still used more extensively. If the latter method is used, the face of the veneer should be serrated in addition to the conventional retention. Serrations will help in retaining whatever material is used.

The numerous commercial masking materials are generally satisfactory. That is, they are satisfactory after the usual experiments. Then the technician is able to approximate a shade on his masking material of choice.

A good masking material should have the following properties: (1) It should have an acrylic base to form positive binding with the veneer material. (2) It should form a thin but opaque covering over the gold. (3) It should not "bleed" through the veneer in processing. (4) It should be chemically stable. (5) It should dry quickly. (6) It should be supplied in various shades. (7) It should have color constancy after processing. There are several materials on the market which satisfy these requirements.

More than one color of masking material may be used on a veneer to attain the desired effects. For instance, a grayish-blue opaque will produce a lighter incisal effect, while an orange-yellow or a pinkish application to the body will give warmth to certain shades. Steele's super-stains may also be used to give desired tint to masking materials.

ALL-ACRYLIC JACKETS

The practicality of all-acrylic jackets has been debated ever since the advent of the material. Objections included its inability to stay on the tooth for long periods of time, and wear of the material. On the other hand, fit was conceded to be better than porcelain and, of course, the friability of porcelain is much greater.

Clinically, we have found the all-acrylic jacket to stand up to porcelain in every respect, and to exceed most of the good qualities of porcelain except in color, which is equal to that of porcelain. It is indispensable on short teeth where the use of conventional porcelain jackets would invite certain failure. I. F. Miller has stated that the substitution of acrylic for porcelain is highly satisfactory, and has demonstrated cases where acrylic jackets have been removed after several years of use with all of the cementing medium still present, and with no recurrent caries or gingival inflammation. Skepticism or adverse opinion may have been created due to poor cementing methods, and to materials used in the early experiences with acrylic jackets.

Acrylic may also be processed on cast gold copings, porcelain copings, or laminated Fiberglass (Fig. 9).

There is serious objection to the use of the unprotected acrylic jacket posteriorly because of wear.

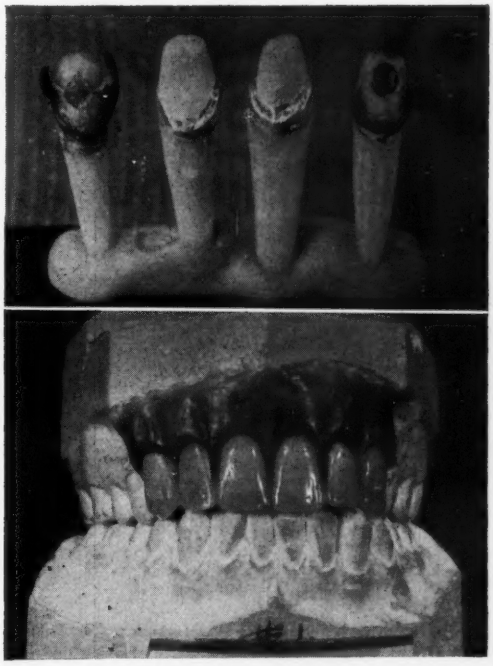
It is interesting to note the comparative hardness of materials commonly used

in the occlusal surfaces of teeth, and to compare this with the hardness of natural enamel and dentine.

Indentation Hardness	*Average Values* (*Knoop Method*) kg./mm. 2
Porcelain (fused)	415
Gold (cast)	62
Acrylic resin	20
Enamel (tooth)	267
Dentine	55

In view of the foregoing, extensive fixed restorations with acrylic occlusal surfaces should not be attempted on permanent restorations. Used in conjunction with gold, however, where the burden of stresses is borne by the gold, the acrylics are most suitable for both bridges and crowns.

A.



B.

Fig. 9.—Acrylic jackets. *A*, Types of cores and thimbles for acrylic jackets. The two end restorations illustrate gold thimbles with lingual shoulders. The one on the left has gold proximal contacts. The two in the center have porcelain cores on which the jackets are to be processed. *B*, Six anterior acrylic jackets processed on various types of copings and thimbles.

WAX-UP

Wax-ups for the veneer, pontics on bridge skeletons, or for straight acrylic jackets, should be made with a wax that leaves no residue after boiling it out (Fig. 10). Colored waxes, i.e., green, blue, red, etc., should never be used. Although alginate separators will prevent contamination of pigment from colored waxes, there may be difficulty in getting a good film of protective covering if there is residue imbedded in the investing material.

INVESTING

Plaster of Paris, mixed to a smooth creamy consistency, is quite satisfactory as an investment material for jackets or bridges. Artificial stones, particularly the colored ones, are objectionable for two reasons. (1) It is a tedious project to deflask restorations invested in stone. (2) White is preferred to other colors as a background for manipulation of shades in the flask.

In investing acrylic jackets, the labial surface and the incisal tip of anterior teeth, and the bucal and occlusal surfaces of posterior teeth should be exposed.

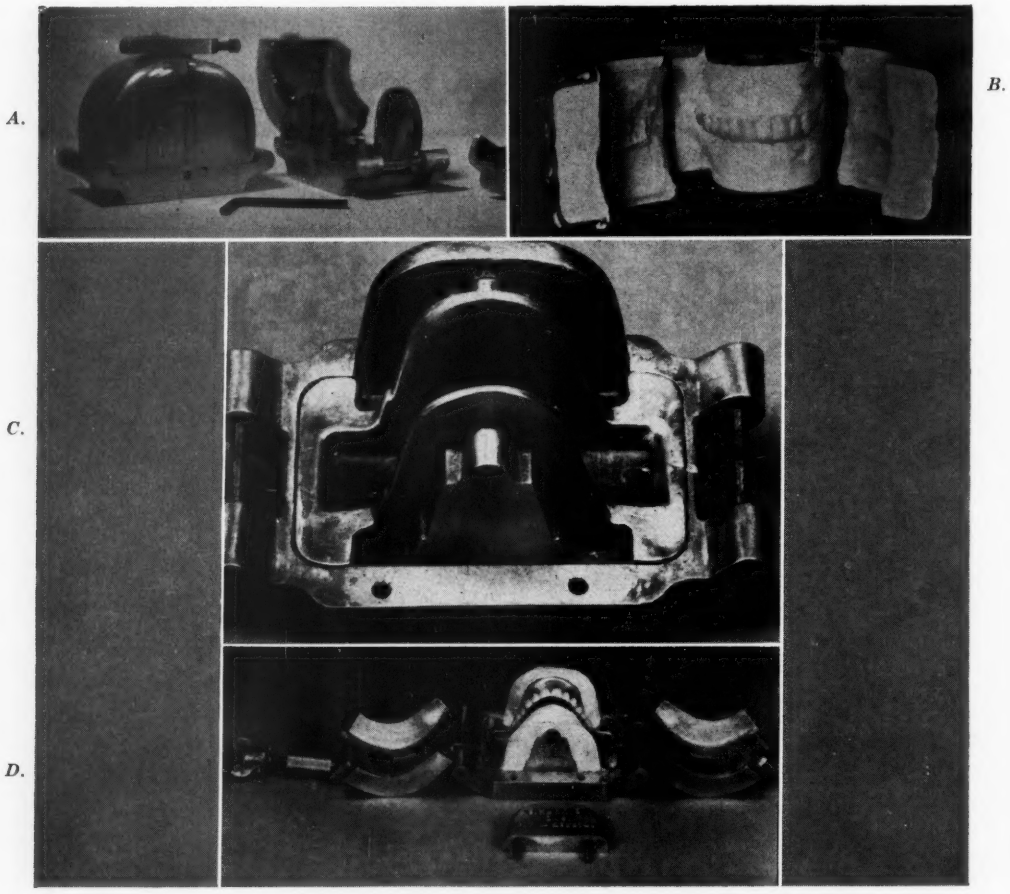


Fig. 10.—Types of flasks for extensive gold-acrylic bridge processing. *A*, Lund flask. *B*, Lund flasks with a bridge invested, packed, and processed. *C*, Harris Knock-Out flask. *D*, Harris Knock-Out flask with a restoration invested.

On bridges and veneers, only the buccal surface is exposed where gold occlusal surfaces are present. The counter is poured in stone as it reflects better detail. For extensive acrylic bridges (Fig. 10), special flasks can save a great deal of laboratory time. These are hinged devices which allow vertical investment of restorations.

TIN-FOIL SUBSTITUTES

Most tin-foil substitutes (separating media) are basically a solution of a soluble alginate which is used with a second hardening solution of calcium chloride. Sodium silicate (water glass) as a base, can also be used.

MIXING AND PACKING ACRYLICS

There are two methods used in packing acrylic jackets and bridges. The first is the "dry-pack" method, where the polymer and monomer are alternately applied directly into the mold until sufficient bulk is built up. The other is the "wet-pack" method, where the polymer and monomer are first mixed in a jar, then put into the mold to replace the boiled-out wax. The latter method is preferable at least for the first trial pack. It allows the operator to mix the mass thoroughly, thus making for reasonably even distribution of the pigments, and the elimination of air spaces.

Factors to be noted when mixing acrylics:

1. Reduce the monomer ratio to the minimum needed in order to reduce the shrinkage. Too much monomer also lightens the shade of the processed acrylic, and reduces its density. Where too much monomer has been used, the cured acrylic will appear opaque, dull, or dead gray. It will look purple under ultraviolet light, particularly so if the acrylic used was not of the fluorescent type.

2. Application of heat, ultraviolet light, or oxidizing agents will hasten the setting of the mixed dough, while cold will retard it.

3. The trial pack should be made with the body shade acrylic which usually constitutes the greatest bulk.

4. Sufficient compression must be assured.

After the trial packs with the body acrylic, the predetermined amount of incisal color is added. The body acrylic is removed from the incisal region by cutting it with a sharp blade. The cut should be on a wavy line rather than a straight cut to avoid an abrupt color change, and it should be done on a bevel. To add the incisal color, the dry-packed method is preferred. It is easier to sprinkle small batches of powder to specific areas than to try to restrict the flow of a doughy material. With this method, a better blend can be brought about between the basic and incisal shades. Any desired characterizations of colors (staining) should be done at this stage in the packing procedure.

STAINING

Wherever possible, the staining material should not be on the surface, but underneath. This can be accomplished by painting a thin layer of clear acrylic over the stained areas, or by making a shallow incision into the body acrylic, and hiding a stronger stain under it. In this way, inorganic mineral stains can be used. This is particularly necessary where stained porcelain replacements are adjacent to a veneer. Using the same stains as were used in the porcelain will accomplish the desired effects. Otherwise for acrylics, organic vegetable stains are indicated.

PROCESSING

Acrylic resins should be processed while the flask is completely submerged in water, under constant compression, in a spring press that allows for the thermal expansion of the resin. While there is no hard and fast rule in processing acrylic resins, we must understand a few pertinent factors. Time-plus-heat is necessary in a proper curing process. The mass in the flask reaches its greatest fluidity at 158° to 194° F. Polymerization occurs at about 167° F., at which temperature it develops rapidly, and in approximately ten minutes it is 95 per cent completed. From this point on, thirty to sixty minutes of boiling are safe with any acrylic. Polymerization starts from the outer surface and progresses inwardly. If it is hastened, free monomer remains in the center. Monomer may be volatilized and the gas so formed is trapped within the mass. This may result in porosity, particularly in bulkier units, such as pontics, etc. Porosity is undesirable because: (1) porosity weakens the structure and resistance to stresses; (2) tiny bubbles collect food residues; porosity is a harbor for bacteria; (3) porosity affects the color of acrylic because of its dispersion of light.

FINISHING

If the separating medium failed, and plaster or stone adheres to acrylic after its removal from the flask, two methods may be used to eliminate it.

1. A small Abbott brush with carding wax applied will remove stone and plaster, but will not harm the acrylic.

2. A saturated solution of sodium citrate will loosen stone or plaster, then a bristle brush and tepid water can be used to remove it. After occlusal adjustments on the cast, the usual finishing tools and instruments are used. It is well to remember, when finishing bridges, that bullet-shaped pontics will create a more hygienic restoration. Never finish acrylic to knife edge. On veneers, finish to the place where the greatest width and depth are gained.

SUMMARY

The use of acrylic resin for crowns and bridges, especially in combination with gold and properly protected by it, affords durable restorations with impact strength. It is easy to finish, polish, and repair. Manipulation of shape and color is limited only by the conditions in the mouth and the skill of the technician. Acrylic resin is biologically compatible with the oral tissues, and when it is properly processed it is impermeable to bacteria.

115 Bentley Ave.
Jersey City, N. J.

SURGICAL CROWN AND BRIDGE PROSTHODONTICS

JOSEPH E. EWING, D.D.S.*

Temple University School of Dentistry, Philadelphia, Pa.

IN THE LAST DECADE there has been an unprecedented trend in the medical and dental professions toward specialization. This has created criticism arising from many directions, to the effect that such trends have produced an "overspecialization." It is not the purpose of this article to enter into a controversial discussions, except to make the following observation: Undergraduate professional students and young practitioners are easily guided and influenced by both their teachers and older practitioners; and it is this writer's belief that our every effort should be directed toward making these embryonic professional persons into good all-round general practitioners, rather than focusing their attentions on special fields of endeavor. All too quickly, in private practice, patients are referred to specialists for treatment, when, in effect, if personal proficiency were developed, such a procedure would not have to be followed. Only at such a time will we be completely fulfilling our responsibility to our patients and to our profession.

The following case history is presented for a twofold purpose: first, to describe its unusual characteristic, and second, to focus attention on the closeness of the fields of oral surgery, crown and bridgework, and prosthodontics. Also, this case history demonstrates the uselessness of shuttling patients back and forth between practitioners for specialized treatment.

EXAMINATION

The patient was a woman between 35 and 40 years of age. Study casts were made from alginate impressions, and a complete roentgenographic study was made as shown in Fig. 1.

The following teeth were missing: Lower right second bicuspid, lower right first, second and third molars, lower left first, second and third molars, upper left first and second bicuspids, upper left first and third molars.

The roentgenographs also disclosed the presence of an impacted upper right third molar. After carefully studying the roentgenographs, it was concluded that the periapical and periodontal tissues were normal, the bone condition satisfactory, and the caries index relatively low.

Upon clinical examination, all teeth responded normally to the vitality test, and the teeth were well developed, of good size, and firmly attached to the alveolus. The patient revealed the fact that she had worn lower partial dentures

Received for publication Jan. 15, 1954.

*Professor, Crown and Bridge Prosthesis.

intermittently, which had proved unsatisfactory. Her immediate problem was the inability to chew properly and increasing soreness of the soft tissue on the posterior part of the lower ridge. The patient aptly described her condition when she said, "I can only chew one way, and if I attempt to chew in any other manner, my jaws become locked."

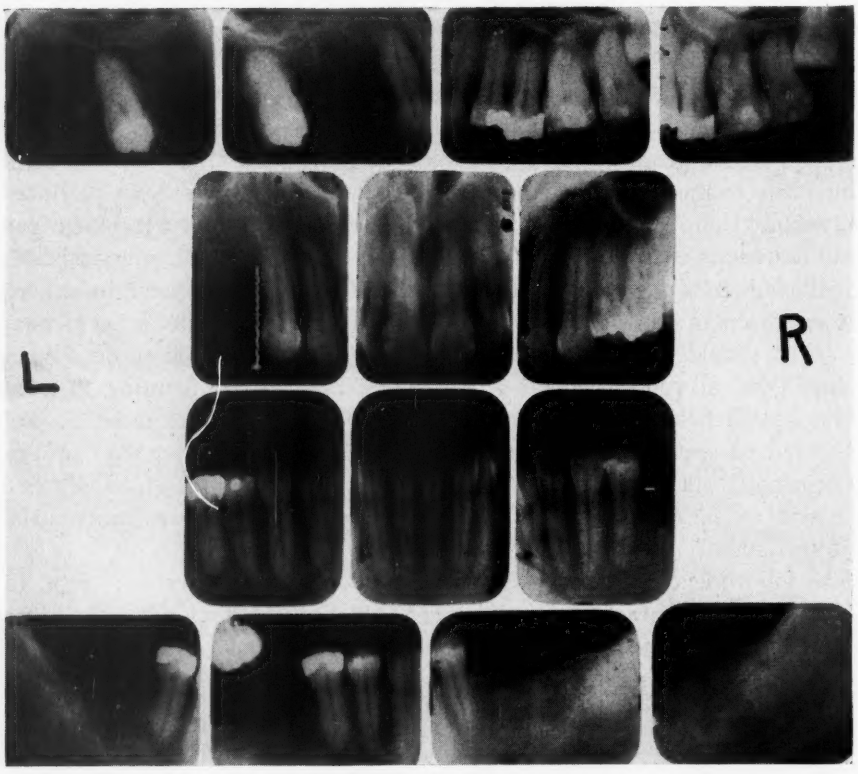


Fig. 1.

SUGGESTED TREATMENT

1. Treatment of all carious areas.
2. Removal of the impacted upper right third molar.
3. Removal of the lower left second bicuspid.
4. Reshaping of the upper molar teeth to establish a new, higher, and more uniform occlusal level.
5. A bilateral mandibular alveolectomy in the molar regions.
6. Acrylic veneer cast gold crowns to be placed on the lower right first bicuspid and lower left first bicuspid teeth.
7. A bilateral distal extension partial lower denture to be retained by either external or internal attachments.
8. A fixed bridge extending from the upper left second molar to the upper left cuspid, the abutment attachments to be a full cast gold crown on the upper left second molar, and an acrylic veneer cast gold crown on the upper left cuspid.

PURPOSE OF TREATMENT

To create and coordinate a *complete* occlusion so that the patient would have better balance, occlusal harmony and greater function, and to prevent trauma in the mandibular alveolar region.

PROCEDURE

The suggested treatment was predicated on the fact that the patient had a normal vertical relationship, and no change seemed likely in the near future (Figs. 2, 3, and 4).

Fig. 2.

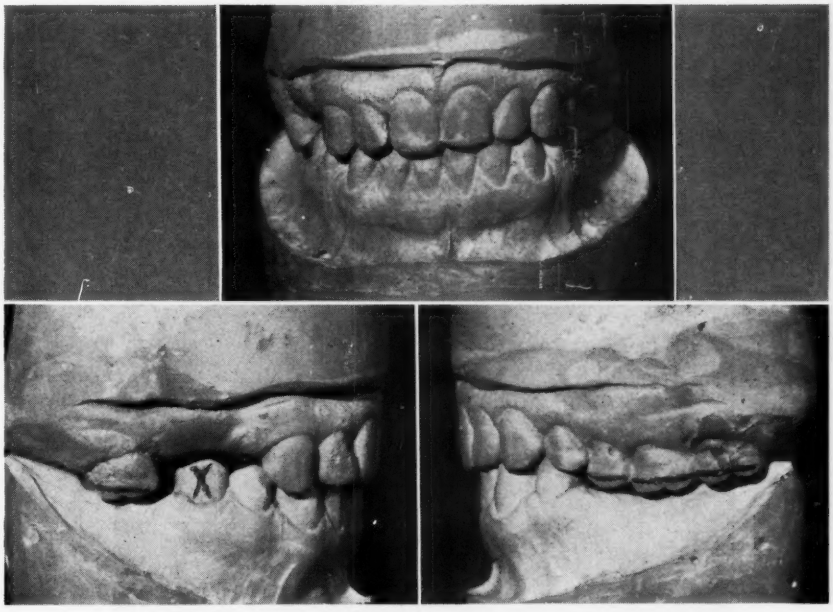


Fig. 3.

Fig. 4.

Treatment was planned in the following order:

1. Removal of the upper right impacted third molar, under local anesthesia. Due to local conditions this was accomplished without undue difficulty, and recovery was rapid.

2. After an interval of one week, the lower left second bicuspid was removed (mandibular block anesthesia); also, at the same time, a left mandibular alveolectomy was done. An incision was made extending from the distal surface of the lower left first bicuspid along the crest of the ridge to the anterior end of the retromolar pad. This tissue was separated, retracted, and the alveolar bone was carefully removed with rongeur forceps. There was no need to remove any large quantities of bone, but rather just the crest of the ridge was removed as normal healing and resorption would produce the space desired. Since it is desirable to

include the retromolar area in the outline of the lower denture, the surgical procedure was not extended into this area. Fig. 5 shows the condition before treatment. Note the lack of space between the posterior teeth and the opposing soft tissue.

3. After an interval of one week, a right mandibular alveolectomy was done under mandibular block anesthesia following the procedure as described in the previous step. Fig. 6 shows the condition before treatment. There was definite contact of the upper right second bicuspid, upper right first and second molars, with the opposing mandibular soft tissue causing soreness and tenderness. Fig. 7 shows the condition after treatment.

4. Over a period of about three weeks at various intervals, the following maxillary teeth were reshaped: upper right second bicuspid, upper right first and second molar. Since the upper left second molar had previously been restored with amalgam, pulp recession had occurred making it possible to reduce this crown to the desired level. The marking as shown in Fig. 3 indicated the amount of anticipated reduction. However, during the operative procedure, it was found that further reduction could be made safely.

Fig. 5. Fig. 6.

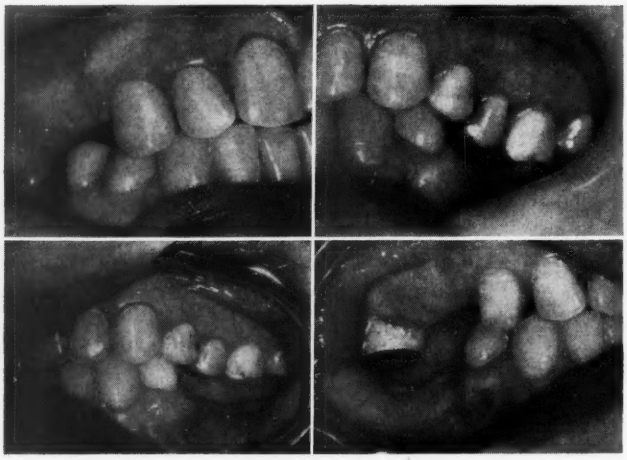


Fig. 7. Fig. 8.

The upper left cuspid was prepared for an acrylic veneer cast gold crown. Since the tooth was in a normal relationship, there were no problems associated with its preparation. Fig. 8 shows results of such treatment. The molar is temporarily covered with an aluminum shell crown after being prepared, and the cuspid tooth is prepared for reception of the acrylic veneer gold cown.

5. Within a very short time, the fixed bridge extending from the upper left second molar to the upper left cuspid was inserted. Result of such a restoration is shown in Fig. 9. Note the amount of intermaxillary space produced after complete healing and reshaping of the teeth in Figs. 9 and 10. Fig. 11 shows an anterior view of this treatment.

6. During the next several visits, acrylic veneer crowns were placed upon the lower right first bicuspid and the lower left first bicuspid teeth, preparatory to the insertion of a removable partial lower denture. Although a precision type

Fig. 9. Fig 10.

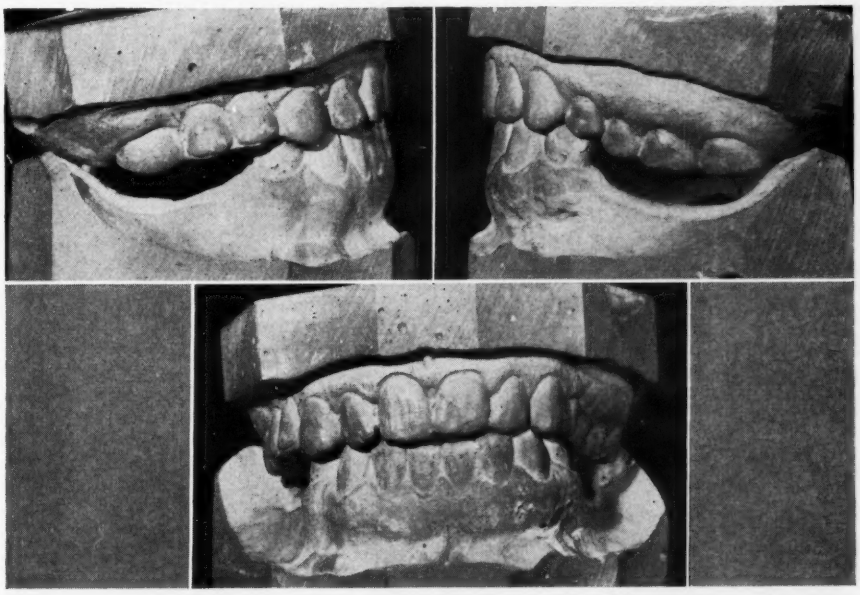


Fig. 11.

Fig. 12.

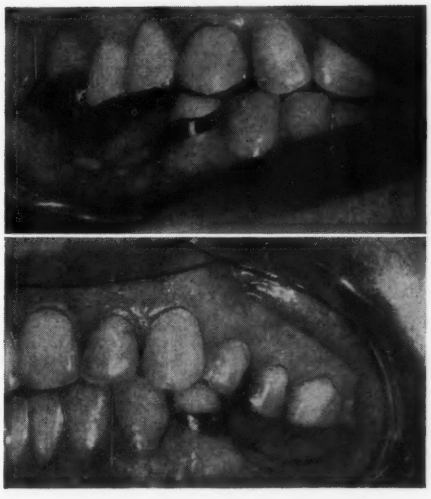


Fig. 13.

of partial denture was recommended, the partial denture was designed with external attachments for economic reasons. Since these teeth seemed favorable clinically and roentgenographically, it was decided to confine full coverage to

these two teeth, and not to include or splint the crowns to the adjacent cuspid teeth. The buccal surfaces of acrylic veneer crowns were so designed that the occlusal two-thirds of these surfaces were veneered with acrylic material, while the gingival one-third was restored with cast gold. The resulting crown gives some degree of esthetics bucco-occlusally, while at the same time it presents a metal surface for the adaptation of clasp arms in the gingival one-third of the veneer crowns (Figs. 12 and 13).

Fig. 14.

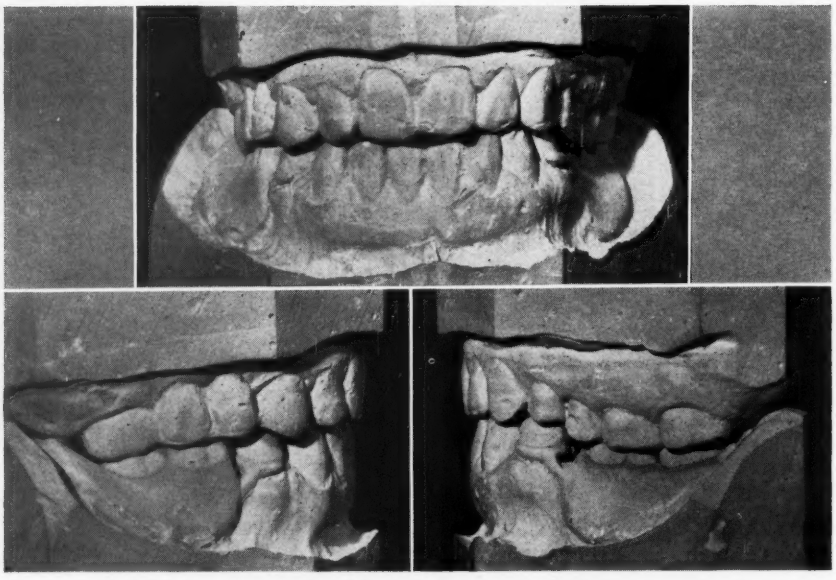


Fig. 15.

Fig. 16.

7. Following standard procedures for impression making, and occlusal registrations, a lower bilateral distal extension partial denture was constructed and inserted. Anticipating that this denture would "settle" after insertion, the intermaxillary space was increased 2 mm. Upon insertion of the denture, the occlusion was carefully coordinated, and good balance was obtained. Due to the fact that a normal vertical and horizontal overlap existed, good occlusal balance was possible in all excursions.

8. After the patient had worn the appliances for a period of three months, she was recalled for observations and correction of her occlusion. This was carried out. Closure of the intermaxillary space was noted to the amount anticipated. The final result is shown in Figs. 14, 15, and 16.

SUMMARY

A bilateral mandibular alveolectomy and the reduction in the gingivo-occlusal height of the opposing maxillary posterior teeth proved to be the solution for the problems associated with this case. However, such a treatment plan is not ad-

vocated for the vast majority of patients with similar situations. Before proceeding with any plan for the removal of mandibular bone, extreme caution should be exercised. This treatment was undertaken for this patient for the following reasons:

1. The patient's age was favorable. Neither a younger nor older patient would have been as favorable.

2. The alveolar bone present was in excellent condition presenting well-formed and well-positioned ridges.

3. There was no loss of normal vertical dimension.

4. Mandibular posterior soft tissues and alveolar bone were being traumatized, and would be lost in some degree under such conditions.

5. Careful examination of the roentgenographs and illustrations will reveal that the maxillary molar teeth were not extruded or elongated. If extrusion had occurred, the clinical crowns of these teeth would have been increased gingivo-occlusally with the resulting exposure of the necks of the teeth. Clinical examination failed to reveal any extrusion, but rather, it disclosed the fact that all the tissues in the entire maxillary molar regions had dropped en masse. Such a condition makes the reshaping of these maxillary teeth easier and more tolerable for the patient.

TEMPLE UNIVERSITY SCHOOL OF DENTISTRY
BROAD ABOVE ALLEGHENY AVE.
PHILADELPHIA 40, PA.

LOAD CAPACITIES OF POSTERIOR DENTAL BRIDGES

R. C. BRUMFIELD, B.S., C.E.

Ridgeville, Ind.

THE PRINCIPLES governing the load-carrying capacities of dental bridges are those of beams, for all such bridges are beams. A beam is any structural member which changes curvature under load. When occlusal loads come upon the dental bridge, it deflects slightly under the influence of those loads, and so changes curvature.

Though the writer realizes that the constructor of a dental bridge is constrained in his design by anatomic considerations not directly related to load-carrying capacity, still the primary purpose of the dental bridge is to carry occlusal loads, and therefore a statement of basic principles governing the structural load-carrying capacities of bridges cannot but be of benefit.

PRINCIPLES GOVERNING LOAD-CARRYING CAPACITIES OF BRIDGES

1. All dental bridges are beams.
2. The load-carrying capacity of a beam varies as:

   (a) Directly as the first power of the beam width (buccolingual). This means that if two bridges are to be compared, except that the width of one is 50 per cent greater than that of the other, then the strength of the wider bridge will be 50 per cent greater (1.5 times as great) than that of the narrower bridge.

   (b) Directly as the square of the depth (occlusogingival). If two bridges are alike, except in depths, they may be compared in load-carrying capacity as follows: Let the depth of one be assumed 100 per cent greater than that of the other (that is, two times the depth of the shallow bridge). The strength of the deeper bridge may be found by multiplying that of the shallow bridge by 2.0 and again by 2.0; that is, the deeper bridge is 2.0 $\times$ 2.0 or 4.0 times the strength of the shallow bridge.

   (c) Inversely as the first power of the span length. If two bridges are alike, except for span length (center to center of abutment teeth for fixed bridges), and it be assumed that the longer span bridge has a distance center to center of abutment teeth which is 50 per cent greater than that of the short span bridge, then the longer span bridge will carry a load which may be found by dividing the load carried by the short span bridge by 1.5, or the strength of the long span bridge is only two-thirds as great as that of the short span bridge.

   (d) Directly as the proportional limit of the material of the bridge. If two bridges are structurally alike, and differ only in the proportional limits of the materials from which the metal portions of the pontics are con-

Received for publication Dec. 23, 1953.

structed, then their comparative strengths may be determined as follows: Let it be assumed that the proportional limit of the material of one bridge is 40 per cent greater than that of the material of the other (i.e., 1.4 times as great). The strength of that bridge which is constructed from the metal with higher proportional limit will then be 40 per cent (1.4 times as great) greater than that of the bridge constructed from the lower proportional limit material.

3. Therefore, from *2b*, the depth of the metal portion of a dental bridge (occlusogingival) is much more influential in determining its load-carrying capacity than is the width of the bridge.

4. Since possible increases in the depth of the metal portions of pontics, or of depth of soldered joints are limited by the anatomy of the mouth, and load-carrying capacity decreases as span length increases (*2c*), it is obvious that longer span bridges have progressively smaller load-carrying capacities than short span bridges. This is true even though the likelihood is increased that the longer bridges will carry greater loads.

5. Principle *4* should suggest that careful consideration be given when long span bridges are being contemplated. With depth limited by anatomy, there must also be a limit to practicable span length. In constructing long span bridges, every available auxiliary device should be employed to strengthen them.

6. Load-carrying capacity varies directly as proportional limit of the metal used in constructing the bridge. It is also true that bending stresses are greater near the middle of the bridge than near the supports. It therefore follows that when the metal portion of pontics are cast from stronger material, the load-carrying capacity of the bridge is increased. Partial denture gold is recommended for the longer span bridges.

7. Though the acrylic or the porcelain portion of the pontic, which is cemented to the labial side of the metal portion, may well add strength to the pontic when under bending load, such additions are too uncertain to be depended upon. In any case, such additions to the metal add nothing to the strength of the soldered joint, whose strength is often the limiting factor for the bridge. Load-carrying capacities of bridges must be assumed to be limited to the bending strength of the metal of the pontic, or of that of the soldered joint, whichever is lower.

8. The limiting load to be placed on the bridge is determined by the proportional limit of the material. Nevertheless, loading types and heat-hardening processes are much too uncertain to permit loading the bridge up to the proportional limit stress. Employment of a reasonable factor of safety dictates that limiting loads be computed to induce stresses in the material equal to not more than 60 per cent of its proportional limit, in the heat-hardened condition.

9. Due to a desire to maintain, in the restoration, the natural form of the teeth, the soldered joint is often not as strong as the pontics which it joins, because of reduced cross-sectional area.

10. Soldered joints, therefore, should always be made as deep (occlusogingivally) as is permitted by the necessities of interproximal cleansing. Attention should also be given to solder thickness (between pontics) and soundness of joints.

11. Soldered joints are thin. Their material, therefore, partakes largely of the strength characteristics of the metal portion of the bulky pontics which they join. Solders up to 650 fine have good strengths in themselves. This fact added to the one first stated, gives assurance that the soldered joint will act as satisfactorily as its limited dimensions will permit.

12. For determining load-carrying capacity, the effective span length of the fixed bridge is from center to center of the abutment teeth. For a fixed-movable bridge (i.e., soldered at one end and supported by an attachment at the other) it is from center of the abutment tooth at the fixed end to the center of contact of the attachment with its abutment.

13. Therefore, other conditions remaining constant, the load-carrying capacity of a fixed-movable bridge would be expected to be slightly greater than that of a fixed bridge of the same dimensions, in the same location.

14. Without regard to cogent physiologic reasons for fixing bridges to their abutment castings, or even of attaching them to more than one abutment at a given end, the load-carrying capacity of a dental bridge is determined from considering it as a simple span. A simple span is one free to rotate at its points of support. This conclusion results because the rotation of an abutment tooth in its peridontal membrane is sufficient to permit to the beam end the theoretical rotation required by a simple beam. Thus effective restraint is precluded.

15. A beam which is appreciably curved, in a direction perpendicular to the direction of application of its load, has its load-carrying capacity greatly reduced. Dental bridges across the anterior portion of the mouth are often of this character. Fig. 1 shows that the occlusal load applied to such bridge has a lever arm tending to rotate the abutments, which rotation is wholly apart from normal bending in a co-planar beam. Such bridges should be constructed with full realization of their limited load-carrying capacities, and of the severe torques they throw into the abutment teeth.

16. Even in posterior portions of the mouth, where the bridge gives the appearance of straightness in a plane perpendicular to the applied load, this appearance is sometimes deceptive. Fig. 2 shows a drawing from actual measurements on a fixed-movable bridge. The solid lines connecting the x's represent the longitudinal axis of the bridge. It is obvious that this broken line would be more nearly straight if the pontic had been soldered slightly nearer to the buccal side of the casting which fits on the abutment. The attachment at the movable end should also have been moved nearer to the buccal surface. Both these matters were subject to the decision of the constructor of the appliance.

LOAD CAPACITIES BASED ON MEASUREMENTS OF THE BRIDGE

Very few measurements have ever been recorded of either dental bridges or soldered joints from bridges. The writer has made some such measurements from bridges submitted by the Crown and Bridge Department of a well-known dental school. Sections of two pontics from these bridges are shown (Fig. 3,*A* and *B*) with over-all dimensions, locations of centers of gravity, and other pertinent data.

These characteristics appear with the sketches of the sections. Similar data are given on Fig. 4 for a typical soldered joint, from the same bridge. The tooth numbers used to designate the pontics are obtained by numbering continuously toward the posterior portion of the mouth, starting from the central as tooth number one.

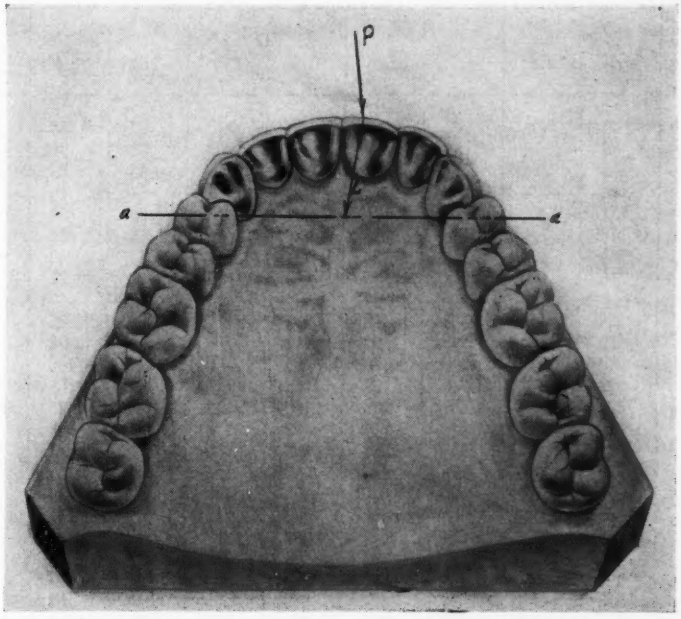


Fig.1.—Illustrating the rotational effect on abutments, produced by occlusal loads on curved bridges in the anterior portion of the mouth. *a-a*, Axis of abutments. *P*, Occlusal load. *L*, Leverage of load producing rotation.

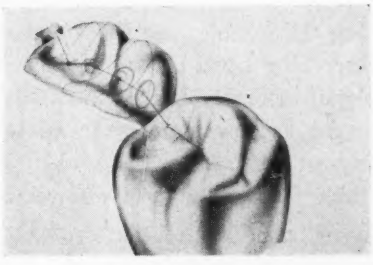


Fig. 2.—Perspective of a fixed-movable bridge showing lack of straightness which may exist.

From the data given in connection with Fig. 3,*A* and *B*, and for the soldered joint, Fig. 4, have been computed load-carrying capacities for dental bridges, not only for these pontics and this soldered joint (SVP values of unity, see tables) but also for all variations of them which are likely to occur in constructing dental bridges. These loads are shown in Tables I and II for the two pontics and in Table III for the soldered joint.

TABLE I. LOAD-CARRYING CAPACITIES OF PONTIC SECTIONS
(See Basic Pontic 4—Fig. 3,*A*)

SECTION VARIATION PRODUCT	ALLOWABLE LOADS ON BRIDGES—POUNDS									
	BRIDGE SPANS—INCHES									
	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8-SPANS
0.3	65	54	46	40	36	32	27	23	20	18
0.4	86	72	62	54	48	43	36	31	27	24
0.5	108	90	77	68	60	54	45	38	34	30
0.6	132	108	93	81	72	65	54	46	40	36
0.7	151	126	108	94	84	76	63	54	47	42
0.8	173	144	123	108	96	86	72	62	54	48
0.9	195	162	138	122	108	97	81	69	60	54
1.0	216	180	154	135	120	108	90	77	67	60
1.1	238	198	169	148	132	119	99	85	74	66
1.2	259	216	185	162	144	130	108	93	81	72
1.3	280	234	200	176	156	140	117	100	87	78
1.4	302	252	216	189	168	151	126	108	94	84
1.5	324	270	231	202	180	162	135	115	100	90
1.6	346	288	246	216	192	173	144	123	107	96
1.7	367	306	262	229	204	183	152	131	114	102
1.8	389	324	278	243	216	194	162	139	121	108
1.9	410	342	292	256	228	205	171	146	127	114
2.0	432	360	308	270	240	216	180	154	134	120
2.1	454	378	324	284	252	226	189	162	141	126
2.2	476	396	339	297	264	238	198	170	148	132
2.3	496	437	354	310	276	248	207	177	154	138
2.4	519	432	370	324	288	260	216	185	161	144
2.5	540	450	385	337	300	270	225	193	167	150
2.6	561	468	400	350	312	280	234	200	174	156
2.7	583	485	416	364	324	292	243	208	181	162
2.8	606	504	432	378	336	302	252	216	188	168

The bases for computing these tables are those stated at the beginning of this section, under Principles Governing Load-Carrying Capacities of Bridges. It is not proposed here to go into detail in describing the methods of computing the tables. It will be sufficient to list the assumptions used and to describe the method of using the tables, for making an estimate of the load-carrying capacity of a dental bridge. In preparing the tables the following assumptions were made:

1. Occlusal load is concentrated at the span center. This condition of loading is simulated by biting on a hard object, such as a bone splinter, located at the span center.

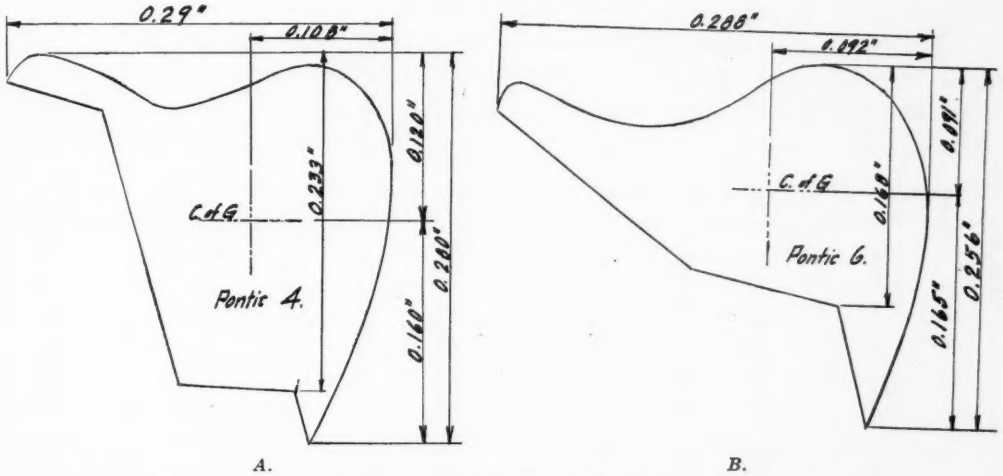
2. The working stress for the material of the bridge as well as for the solder of the joints, is 27,000 psi. This is 60 per cent of the proportional limit (45,000 psi) of a typical Type III inlay gold in its heat-hardened condition.

3. The beam, which the bridge constitutes, is essentially straight and acts as a simple span.

4. Shapes of sections are similar, in general outline, to those shown in Figs. 3,*A* and *B*, and 4.

5. The metal of the pontic carries all the bending load. Any effect of cemented acrylic or porcelain is ignored.

As a result of uncertainties of many kinds, the results shown in the tables of load-carrying capacity are not exact. They do, however, represent a very intelligent estimate of the occlusal load which may safely be imposed upon the bridge. As such, they should be of substantial benefit to those interested in the improvement of bridgework.



A. B.

Fig. 3.—Measured cross sections of pontics from actual bridges in the same mouth. *A*, Cross section of metal of Pontic 4. Characteristics: area, 0.039 square inch; movement of inertia, 0.00015 inch;[4] section modulus, 0.0010 inch.[3] *B*, Cross section of metal of Pontic 6. Characteristics: area, 0.030 square inch; movement inertia, 0.000057 inch;[4] Section modulus, 0.0005 inch.[3]

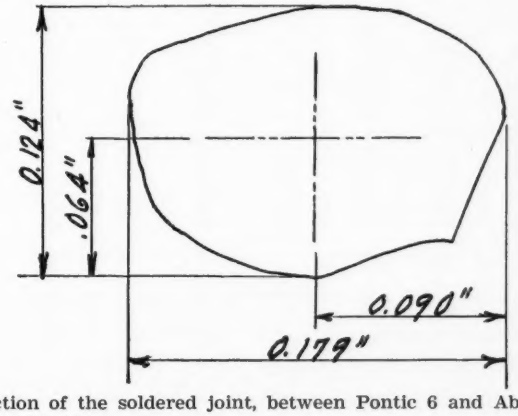


Fig. 4.—Cross section of the soldered joint, between Pontic 6 and Abutment 7 from actual measurements on a dental bridge.

THE USE OF TABLES OF LOAD-CARRYING CAPACITY

Tables I, II, and III have been computed for a great number of step variations in the metal portions of the basic pontics or of the joint shown, respectively, in Figs. 3,*A* and *B* and 4. In order to enter these tables to make an estimate of the load-

carrying capacity of a bridge, having somewhat similar pontics and joints to those used for the tables, it is necessary to have comparison yardsticks. These are termed Width Variation Factor, for widths of sections; Depth Variation Factor, for depths of section; and finally from these is computed the Section Variation Product, with which the tables are entered. For brevity these respective terms are shortened to WVF, DVF, and SVP.

TABLE II. LOAD-CARRYING CAPACITIES OF PONTIC SECTIONS
(See Basic Pontic 6—See Fig. 3,*B*)

SECTION VARIATION PRODUCT	ALLOWABLE LOADS ON BRIDGES—POUNDS									
	BRIDGE SPANS—INCHES									
	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8-SPANS
0.3	32	27	23	20	18	16	14	12	10	9
0.4	43	36	31	27	24	22	18	16	14	12
0.5	54	45	38	34	30	27	22	19	17	15
0.6	65	54	46	41	36	32	27	23	20	18
0.7	76	63	54	48	42	38	31	27	24	21
0.8	86	72	62	54	48	43	36	31	27	24
0.9	97	81	70	61	54	49	41	35	31	27
1.0	108	90	77	68	60	54	45	39	34	30
1.1	119	99	85	75	66	59	50	43	37	33
1.2	130	108	92	82	72	65	54	47	41	36
1.3	140	117	100	88	78	70	59	51	44	39
1.4	150	126	108	95	84	76	63	55	48	42
1.5	162	135	116	102	90	81	68	59	51	45
1.6	173	144	123	109	96	86	72	62	55	48
1.7	184	153	131	116	102	92	77	66	58	51
1.8	194	162	139	123	108	97	81	70	61	54
1.9	205	171	146	129	114	103	86	74	65	57
2.0	216	180	154	136	120	108	90	78	68	60
2.1	227	189	162	143	126	114	94	82	71	63
2.2	238	198	169	150	132	119	99	86	75	66
2.3	248	207	177	156	138	124	103	90	78	69
2.4	260	216	185	163	144	130	108	94	82	72
2.5	270	225	193	170	150	135	112	98	85	75
2.6	280	234	200	177	156	140	117	101	89	78
2.7	292	243	208	183	162	146	121	105	92	81
2.8	300	252	216	190	168	151	126	109	95	84

The Width Variation Factor (WVF) is found by dividing the width in inches of that section whose carrying capacity is to be estimated by the width of the section to which it is to be compared, as shown in Fig. 3,*A* and *B*, or 4, as the case may be. The following example will make this clear. Let the section of the metal portion of a pontic be considered to be more nearly similar to that shown for pontic No. 6 (Fig. 3,*B*) and its width be 0.256 inch. The width variation factor then is found by dividing 0.256 by the similar dimension for pontic No. 6, namely, 0.288 (Fig. 3,*B*). Thus:

$$\text{WFV} = \frac{0.256}{0.288} = 0.89$$

Similarly the depth variation factor (DVF) is found by making an exactly similar division of the corresponding depth of the basic pontic into that of the compared section.

Two depths are shown on the figures of the sections of the metal portions of the basic pontics. These are the over-all depth from the occlusal platform to the lower tip of the skirt, on the lingual side, and the distance from the occlusal platform of the metal portion of the pontic to the lower edge of the ridge platform. It is recommended that, in estimating load-carrying capacity, the latter dimension be used as the effective depth of the pontic metal rather than the former. This depth is chosen because it is that dimension most influential in determining section characteristics. The skirt of the pontic is more in the nature of an excrescence on the section, and wide variations in its dimension can have little effect on the section characteristics, because its volume is small.

Assuming the depth to the ridge platform of the metal portion of the pontic is 0.20 inch, for the compared section, then the DVF value for this section is:

$$\text{DVF} = \frac{0.20}{0.168} = 1.19$$

Neither the division for the WVF nor the DVF values need actually to have been made. Either value can be read directly from the chart of Fig. 5. Thus entering the chart at 0.2 (as mentioned previously) on the vertical ordinate and following horizontally across to the straight line marked Depth (No. 6) the value 1.19 may be read from the horizontal scale, vertically beneath this point.

SECTION VARIATION PRODUCT

The Section Variation Product, with which value the tables of load-carrying capacity are entered, is obtained from the values of WVF and DVF by simple multiplication. The section variation product (SVP) is equal to the value of WVF multiplied by the value of DVF, and this result again multiplied by the value of DVF. Thus, for the section whose factors were computed above:

$$\text{SVP} = 0.89 \times 1.19 \times 1.19 = 1.26$$

This last multiplication also need not actually have been made. The result can be read directly from the curves of the chart of Fig. 6. This is done as follows: Enter the vertical ordinate of the chart of Fig. 6 with the DVF value of 1.19. Follow horizontally across to the curved line. Now move vertically up (or down as necessary) to 0.89, the value of WVF. From this point move horizontally across to the righthand scale and read SVP as 1.26 from this scale. The straight lines which represent WVF show tenth and two-tenths step variations. It is necessary to estimate intermediate distances. This can easily be done with sufficient accuracy. The values of DVF, WVF, and SVP, which are shown by lines and arrows on the figure, to illustrate the use of the chart, are, respectively, 1.545, 0.87, and 2.07. The arrows indicate the procedure in making the estimate.

ESTIMATED LOAD-CARRYING CAPACITY

Once the value of SVP has been obtained, the estimated load-carrying capacity of the bridge may be read directly from the appropriate table. Thus, as previously mentioned, SVP was found to be 1.26. The pontic was compared to that whose metal section was shown as No. 6. Entering Table II, which gives load capacities for variations of No. 6, at the SVP value of 1.3 (nearest to 1.26 obtained) a load capacity of 59 pounds is read under the assumed span of 1.2 inches. This is the load which bending in the pontic will permit. The soldered joint may modify this conclusion. This will be discussed later. A slightly closer estimate could have been made by interpolating between the SVP values listed in the table in order to obtain a load for an SVP of 1.26, instead of 1.3. This refinement is seldom necessary.

LOAD CAPACITY TABLES SHOULD CHECK EACH OTHER

The sections of the metal portions of pontics 4 and 6 are similar in shape. Though Tables I and II for these two pontics were computed independently, they still should check each other reasonably well, if the basic assumption of load estimation by comparison is a sound one. This check will be made by comparing Pontic 6 to Pontic 4, which will be assumed the basic section. The load-carrying capacity of a bridge constructed from sections like Pontic 6 will be estimated from Table I and checked by comparing the result obtained with the value shown for the same span, under an SVP value of unity in Table II. The loads obtained by the two methods should substantially check.

From Fig. 3,*A* and *B*:

$$\text{WVF} = \frac{0.288}{0.290} = 0.99 \qquad \text{DVF} = \frac{0.168}{0.233} = 0.72$$

$$\text{SVP} = 0.99 \times 0.72 \times 0.72 = 0.512$$

Let the span length be assumed 1 inch. Enter Table I at an SVP of 0.5 (nearest to 0.512 obtained) and read under a span length of 1.0 inch, the estimated carrying capacity of 54 pounds for the bridge. Now enter Table II at an SVP of 1.0 and read the same 54 pounds under a span of 1.0 inch as the load-carrying capacity of the same pontic compared to itself. In this case the check was exact. Similar comparisons can be made for other spans, with results which check closely. Such comparisons should give confidence in the correctness of the tables. Either table would serve alone, but both are included since pontics vary considerably. The inclusion of both sections gives opportunity for comparison to the more similar section whether the pontic being compared be deep or shallow.

SOLDERED JOINTS MAY BE IMPROVED IN STRENGTH

It has been emphasized that soldered joints or connectors should be as deep as possible in order to show strengths comparable to those of the pontics which they join. The joint of Fig. 4 was used in joining the metal of Pontic 6 to the abutment casting of Tooth 7. The depth of the joint is shown in the figure to be 0.124 inch. Since the ridge platform of the metal portion of the pontic is 0.168 inch below

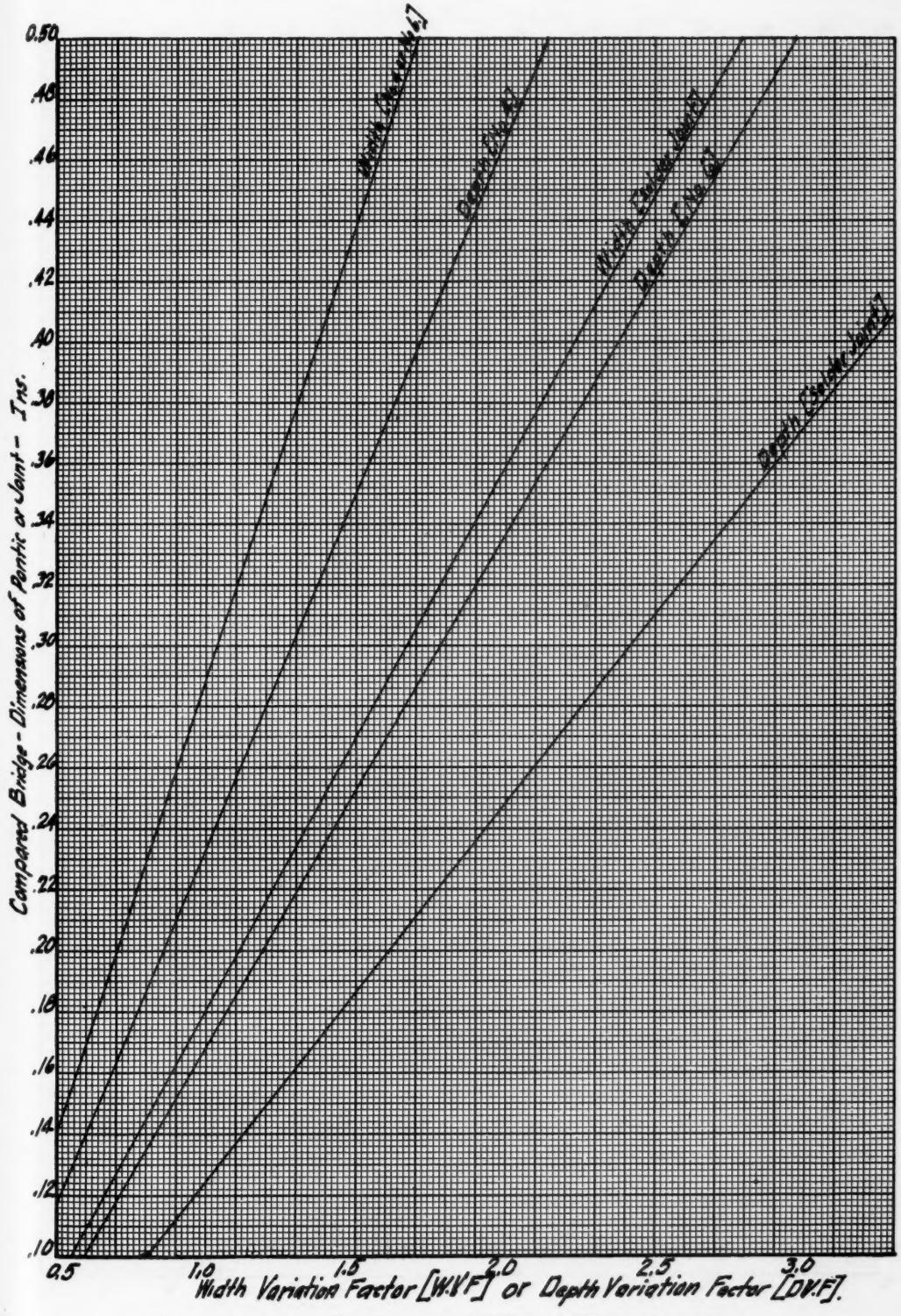


Fig. 5.—Chart for reading the value of WVF and DVF, starting with the dimensions of the pontic joint.

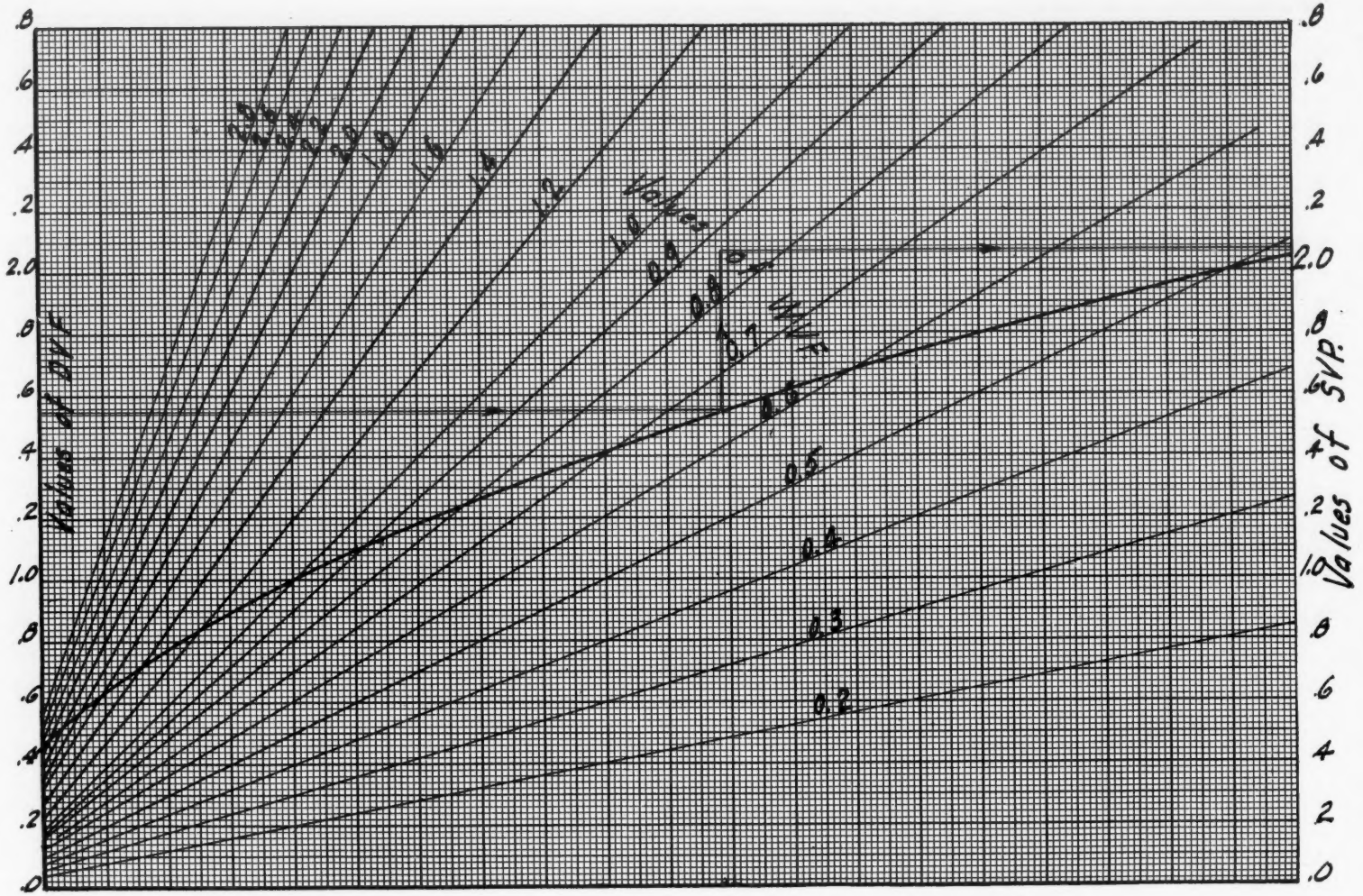


Fig. 6.—Chart for obtaining the value of SVP from the values of DVF and WVF, read from chart of Fig. 5.

the occlusal, it is not unreasonable to assume that the depth of the joint might be increased to 0.150 inch without interfering with cleansing between the teeth. Let it be assumed that the joint width remains unchanged. On this basis:

$$WVF = 1.0, \qquad DVF = \frac{0.150}{0.124} = 1.21$$

$$SVP = 1.0 \times 1.21 \times 1.21 = 1.47$$

Entering Table III at an SVP value of 1.5 (nearest to 1.47 and half way between 1.4 and 1.6) the strength of the bridge, based on the joint assumed at span center, is seen to be 78 pounds for a half inch span. This represents an increase in strength of 26 pounds, or over 50 per cent of that it has under the dimensions shown in the sketch, and also under an SVP of unity in the table.

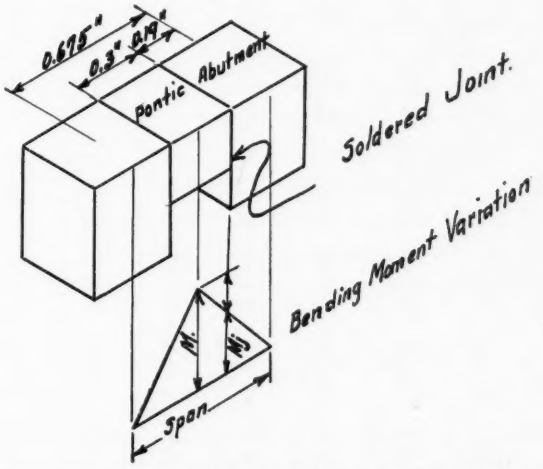


Fig. 7.—Diagrammatic perspective of a bridge, illustrating the method of estimating strength of joint when not at the center.

SOLDERED JOINTS NOT AT SPAN CENTER

Fig. 7 shows a diagrammatic sketch of a single pontic fixed bridge. In this case as with any bridge with an odd number of pontics, the soldered joint does not lie at the span center. Hypothetical dimensions will be assigned to the pontic and to the soldered joint, as this bridge will be used to summarize the method of estimating bridge strength, as well as of handling the case of soldered joints which do not lie at the center of the bridge span.

Assume:

Pontic width is	0.26 inch
Depth to ridge platform	0.18 inch
Joint width is	0.19 inch
Joint depth is	0.16 inch

Fig. 6.—Chart for obtaining the value of SVP from the values of DVF and WVF, read from chart of Fig. 5.

TABLE III. LOAD-CARRYING CAPACITIES OF SOLDERED JOINTS
(SEE BASIC JOINT 6-7, FIG. 4)

SECTION VARIATION PRODUCT	LOCATION OF JOINT IN SPAN	ALLOWABLE LOADS ON BRIDGES—POUNDS									
		BRIDGE SPANS—INCHES									
		0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.2	1.6	1.8
0.3	Center	16	13	11	10	8	8	7	6	5	4
	3/8 Span	21	17	15	13	11	11	9	7	7	5
	1/4 Span	32	26	22	20	16	16	14	10	10	8
0.4	Center	21	17	15	13	11	10	9	7	6	6
	3/8 Span	28	23	20	17	15	13	12	9	8	8
	1/4 Span	42	34	30	26	22	20	18	14	12	12
0.6	Center	31	26	22	19	17	16	13	11	10	8
	3/8 Span	41	36	29	25	23	21	17	15	13	11
	1/4 Span	62	52	44	38	34	32	26	22	20	16
0.8	Center	42	34	30	25	22	21	18	14	13	11
	3/8 Span	56	45	40	33	29	28	24	19	17	15
	1/4 Span	84	68	60	50	44	42	36	28	26	22
1.0	Center	52	42	37	32	28	26	22	18	16	14
	3/8 Span	69	57	49	43	37	35	29	24	21	19
	1/4 Span	104	86	74	64	56	52	44	36	32	28
1.2	Center	62	52	44	38	34	31	26	22	19	17
	3/8 Span	82	69	59	50	45	41	35	29	25	23
	1/4 Span	124	104	88	76	68	62	52	44	38	34
1.4	Center	73	60	52	45	39	36	31	25	22	20
	3/8 Span	97	80	69	60	52	48	41	33	29	27
	1/4 Span	146	120	104	90	78	72	62	50	44	40
1.6	Center	83	69	59	51	45	41	35	29	26	22
	3/8 Span	110	92	78	68	60	54	46	39	35	29
	1/4 Span	166	138	118	102	90	82	70	58	52	44
1.8	Center	94	77	67	58	50	46	40	32	29	25
	3/8 Span	125	102	89	77	66	61	53	43	39	33
	1/4 Span	188	154	134	116	100	92	80	64	58	50
2.0	Center	104	86	74	64	56	52	44	36	32	28
	3/8 Span	138	114	99	97	76	69	59	48	43	37
	1/4 Span	208	172	148	128	112	104	88	72	64	56
2.2	Center	114	95	81	70	62	57	48	40	35	31
	3/8 Span	152	126	108	93	83	76	64	53	47	41
	1/4 Span	228	190	162	140	124	114	96	80	70	62
2.4	Center	125	103	89	77	67	62	53	43	38	34
	3/8 Span	166	137	118	102	89	82	71	57	50	45
	1/4 Span	250	206	178	154	134	124	106	86	76	68
2.6	Center	135	112	96	83	72	67	57	47	42	36
	3/8 Span	180	149	128	110	96	89	76	63	56	48
	1/4 Span	270	224	192	166	144	134	114	94	84	72
2.8	Center	146	121	104	90	79	73	62	50	45	39
	3/8 Span	194	160	137	121	104	98	81	67	59	53
	1/4 Span	292	242	208	180	157	146	123	101	90	79

Computing as previously described (Pontic 6 as a basis)

For the pontic	For the joint
$WVF = \frac{0.26}{0.288} = 0.9$	$WVF = \frac{0.19}{0.179} = 1.06$
$DVF = \frac{0.18}{0.168} = 1.07$	$DVF = \frac{0.16}{0.124} = 1.29$

$SVP = 1.06 \times 1.29 \times 1.29 = 1.76$ (For the joint)
$SVP = 0.9 \times 1.07 \times 1.07 = 1.03$ (For the pontic)

For the load capacity of the bridge, based on the metal section of the pontic and an assumed span of 0.7 inch (Table II).

Load capacity based on the pontic. . . . . 77 pounds.

Load capacity based on the joint: It will be noted from Fig. 7 that the soldered joint is not at the span center but is located 0.19 inch from the center of the nearest of the fixed abutments. The variation of the bending moment resulting from the central load is shown on the sketch, below the figure. If the joint was located at the span center it would of necessity sustain M, the maximum bending moment. Located as it is to the right of the center it sustains a lesser bending moment, Mj. With this location, it is therefore capable of withstanding more central load than it would if located at the span center. Table III provides for joints located off center and assigns to them increased load-carrying capacities.

The location of the particular joint of this problem is $\frac{0.19}{0.675} = 0.28$ of the span length from the nearest support. Quarter span is the nearest location to this which is listed in Table III. Reading in the table under a joint location of 0.25 and a span of length of 0.7 inch with an SVP value of 2.0 (nearest to 1.76).

Joint located at quarter point: Load capacity based on joint. . . . . 148 pounds.

Since this load is much greater than that obtained from the metal section of the pontic, the effective load capacity of the bridge is 77 pounds. If the joint had been located at span center, Table III shows that its load capacity would have been reduced to 74 pounds, or less than that which the pontic is capable of carrying.

Should decision be made to use a partial denture gold (P.L. 75,000 psi, heat hardened) for the construction of this bridge rather than the Type III inlay gold which the tables contemplate, the increased load-carrying capacity of the above bridge is readily obtained by multiplying the 77 pounds obtained, by the ratio of the proportional limits of the two golds, thus:

$$\text{Load Capacity} = 77 \times \frac{75}{45} = 129 \text{ pounds}$$

MEASUREMENTS FOR ESTIMATING LOAD CAPACITY

There are at least two different viewpoints from which to make an estimate of the load-carrying capacity of a dental bridge. First, and probably most important, it is necessary to estimate the load-carrying capacity of a bridge which is not yet in existence. This is done in planning a proposed bridge. In such case, the dentist has only the cast of the mouth showing the edentulous area which the bridge will restore. In the second case, it may be occasionally necessary to investigate the load capacity of the bridge already built, where actual pontics and joints exist which may be measured. It is clear that the two cases present somewhat different problems of measurement.

In planning a bridge, not yet constructed, the procedure is somewhat as follows: A straightedge is laid across the cusps of the abutment teeth which are adjacent to the edentulous area. The space between the ruler and the ridge is then determined by setting an inside caliper and taking a measurement from its tips by means of a micrometer, a Boley gauge, or even a scale reading in hundredths of an inch. The space, so determined, is available for the metal portion of the pontic; for the acrylic which the dentist wishes to interpose between the metal and the tissue; and for whatever clearance he deems necessary between the acrylic and the tissue. He must rely upon his experience in allocating the space to these three uses. It should be remembered, however, that if space is small, as much of it as possible should be given to the metal portion of the pontic in order to provide a bridge of adequate load capacity. Thus, in practice, the depth of the metal portion of the pontic is predetermined. It is only necessary that the dimensions fixed upon be adhered to in the construction of the wax patterns for the pontics. Wax patterns may be checked on this point, with sufficient accuracy, by the use of such an instrument as the Boley gauge.

Width measurements of pontics are also determined as a result of measurements of the existing abutment teeth. Depths and widths of connectors or soldered joints are predetermined from the use of Table III, considered in connection with measurements of existing abutment teeth. These dimensions of solder are fixed in the bridge by the use of flux and antiflux, when preparation is made for soldering the bridge.

When an actual bridge exists, whose load capacity is to be investigated, measurements of both the metal portions of pontics and of soldered joints are to be made. For doing this, the author prefers an instrument such as an Ames Dial (reading to 0.001 inch) mounted on a block. The anvil, upon which the object to be measured is placed, and the dial stem above it should each carry a point. These two points should be directly in the line of movement of the dial stem. A darning needle, with point slightly flattened, is satisfactory for these. Such points are convenient for getting into the interproximal spaces between pontics, as is necessary for measuring soldered joints. A setup of such a dial, so equipped, is shown in Fig. 8. The cost is relatively small and it may be used for many other purposes.

SIGNIFICANCE OF ESTIMATED LOAD-CARRYING CAPACITIES

Estimated load-carrying capacities can have little significance without a standard of comparison. The obvious standard is the biting pressures on the natural teeth. Table IV gives a list of such biting pressures in terms of pounds. The data for the table was obtained by a competent research staff of a recognized dental school, and may be relied upon as accurate.

Fig. 8.—Arrangement of an Ames Dial for measuring pontics or joints.

The author does not presume to lay down, for the dental profession, the exact rules for interpreting these data as a yardstick for determining whether or not the load-carrying capacity is satisfactory for a particular bridge in the mouth, since biologic considerations may also be involved. Often the biting pressures listed in Table IV will be greater than the estimated load-carrying capacity of the bridge. In the absence of a fixed rule for interpreting the pressures of the Table, it is possible to set down some guiding principles upon which each individual may base a judgment of the adequacy of the load-carrying capacity of a particular bridge.

TABLE IV. MEASURED BITING PRESSURES ON NATURAL TEETH*

UPPER TEETH			LOWER TEETH		
TOOTH† NUMBER	PRESSURES (POUNDS)		TOOTH† NUMBER	PRESSURES (POUNDS)	
	MEAN	PROBABLE MAXIMUM		MEAN	PROBABLE MAXIMUM
1	60	95	1	55	80
2	55	90	2	55	80
3	80	120	3	75	130
4	100	150	4	95	150
5	110	165	5	115	165
6	130	220	6	130	220
7	125	200	7	125	200

*Printed by permission. Measurements taken on natural teeth in the human mouth, by the Research Staff of a dental school.

†Tooth numbers obtained by starting with the central incisor as No. 1 and numbering continuously toward the posterior portion of the mouth.

ADEQUATE LOAD-CARRYING CAPACITY

1. If the estimated load-carrying capacity of a particular bridge is equal to or greater than the biting pressures shown in Table IV, for the teeth replaced by pontics, the bridge may be considered entirely satisfactory as a load-carrying device.

2. Measurements have proved that the wearer of a restoration seldom bites upon it with as great a force as he would have used on his natural teeth.

3. When pontics are constructed narrower than the natural teeth which they replace, it is less likely that they will sustain the full biting pressures listed for the natural teeth.

4. A patient with a heavily muscled mouth may be expected to bite on his natural teeth with forces more nearly equal to those listed in Table IV under the columns of Probable Maximum Pressures. The usual patient would be compared to figures in the columns representing Mean Pressures.

5. If the bridge carries more than one pontic, it is unlikely that the total maximum load on the bridge would be the sum of the pressures listed in the table for the teeth replaced by pontics. When the bridge carries more than one pontic, the sum of the biting pressures of the table for the teeth represented by those pontics should be reduced by some arbitrarily chosen percentage before comparison is made. Thus the author estimates that 70 per cent of this sum might be used when two pontics are involved, 50 per cent for three pontics, etc.

6. As the estimated load-carrying capacity of the bridge falls increasingly below the biting pressures listed for the natural teeth replaced, the constructor of the appliance should feel more unsure of the satisfactory service of the bridge, and should realize that its eventual failure is a distinct possibility.

Considering the bridge analyzed under the heading, Soldered Joints May Be Improved in Strength, and assuming the pontic represents Tooth 4, these conclusions may be tentatively set down:

(a) The estimated carrying capacity of 77 pounds is only 77 per cent of the 100 pounds listed in Table IV for Pontic 4.

(b) If the anatomy of the mouth permits making the pontic and joint deeper, this should be done. A partial denture gold could be used to raise load-carrying capacity.

(c) From 2, previously mentioned, it is probable that 77 per cent of the biting pressure listed for the natural tooth would be satisfactory.

(d) Had the discrepancy between estimated load and biting pressure been greater, with estimated load only 30 per cent of that given in Table IV, a grave question would have arisen as to whether the proposed bridge should be used for the restoration.

It is believed that analyses, similar to those indicated, will be of benefit to men interested in improving the quality and serviceability of their bridgework.

Route 1
Ridgeville, Ind.

DENTURE BASE DEFORMATION DURING FUNCTION

CARL P. REGLI, D.D.S.,* AND HERBERT L. GASKILL, B.S., M.S., IN CH.E.**

University of Washington School of Dentistry, Seattle, Wash.

FORCES INITIATED by the muscles of mastication create stresses at the occlusal surfaces of the teeth. These stresses are distributed to the mandible through the medium of the denture base. Certain variables will influence this distribution, such as the capacity of the musculature to exert force, the tooth size, the type and position of teeth, varying characteristics of the supporting structures, and differences in impression procedures. It is believed that the function of the base to adequately distribute these stresses is partially dependent upon the ability of the denture base to resist deformation.

PURPOSE

The objective of this article is to present data relative to the direction and magnitude of deformation during mastication and deglutition in three types of denture bases (Fig. 1).

MATERIALS AND METHOD

Four patients were selected for this study. Two patients presented high ridges and two patients presented flat ridges. All patients exhibited normal ridge relationships and bilateral symmetry of facial characteristics.

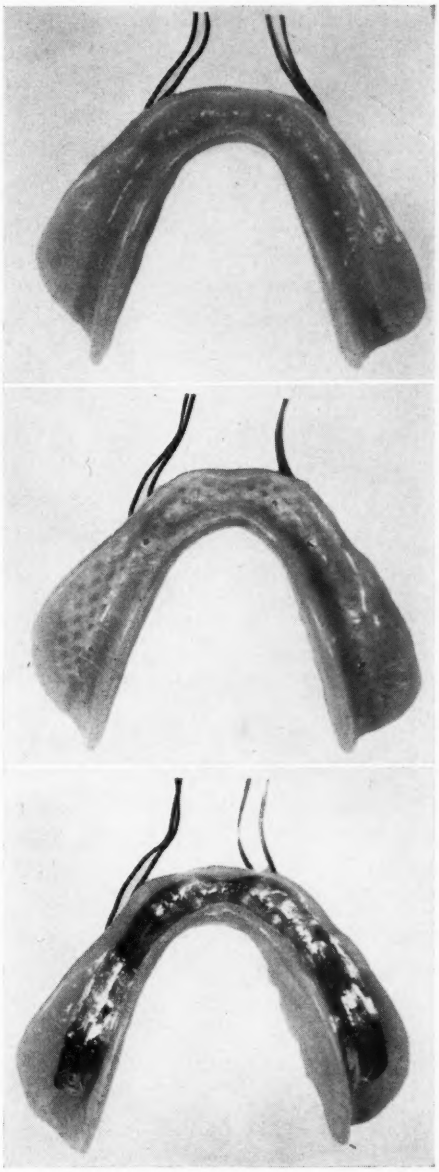
A complete upper and three complete lower dentures with differing bases (methyl methacrylate, methyl methacrylate with a cast metal insert, and metal base [Fig. 1]), were constructed for each of the four patients using cusp teeth. The lower dentures for each patient were fabricated in a manner to be as similar as possible with the exception of the bases. A split mold was made of the first denture after the teeth were set up and the contouring was completed in wax. This mold was used to position the teeth on duplicate casts, and baseplate wax was injected into it to form a similar contour and bulk in the duplicate dentures.

APPARATUS

The apparatus employed in this investigation was essentially the same as was described in a previous article.[1] Two SR-4 strain gauges were bonded to the lingual portion of the lower denture at the midline. The longitudinal axis of each of the gauges was parallel to the incisal edges of the anterior teeth, and they

Read before the American Denture Society, Cleveland, Ohio, Sept. 25 to 26, 1953.
Received for publication Dec. 28, 1953.
*Associate Professor, Department of Prosthodontics.
**Assistant Professor, Department of Dental Materials.

were located at the center of the upper half, and the lower half, respectively, of the lingual flange (Fig. 2). A two channel Brush pen recorder was utilized to obtain inked records of the deformation occurring in the denture base while the patient drank water, and chewed peanuts and carrots.



A.

B.

C.

Fig. 1.—Lower dentures. *A*, Methyl methacrylate; *B*, methyl methacrylate with metal insert; and *C*, methyl methacrylate with metal base.

This method of gauging provided for the observation of the following types of deformation of the denture base:

1. Extension—a simple spreading apart of the denture (Fig. 3,*A*).
2. Compression—a simple moving together of the denture (Fig. 3,*B*).
3. Torsion—a compound movement wherein, viewed from the posterior aspect, the flanges of the denture are torqued in opposite directions of rotation; i.e., the teeth are rotated buccally and the lingual flanges rotated lingually. In this case, the upper portion of the anterior lingual flange (upper strain gauge) is elongated and the lower portion (lower strain gauge) is compressed (Fig. 3,*C*).
4. In addition, the use of two strain gauges provided information as to the relative amount of deformation occurring in the upper portion as compared to the lower portion of the denture.

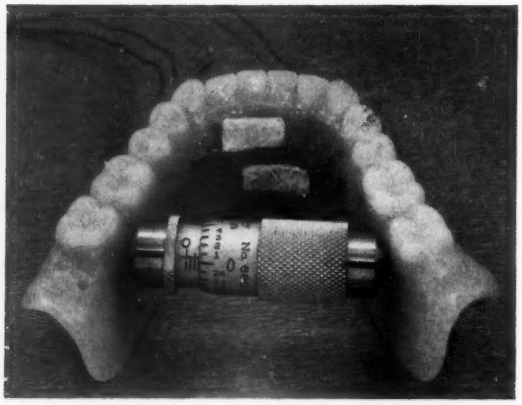


Fig. 2.—Strain gauge positioning and inside micrometer measurement for direct calibration of extension.

The measure of the amount of deformation was arbitrarily established as the linear change in the distance between second molars on opposing sides of the denture. An absolute calibration of the strain gauges for extension was obtained by use of an inside micrometer (Fig. 2). An outside micrometer bearing below the buccal surface of the second molar was used for the calibration of compression.

Since it was not possible to calibrate torsional deformation in terms similar to extension or compression, the movement reported is not linear in the case of torsional deformation, but rather it is an algebraic sum of the upper and lower strain gauge recordings.

RESULTS

The values of deformation for the twelve denture bases investigated during function are tabulated in Table I.

MASTICATION

During mastication the denture bases of Patients A and B (high ridge) deformed in the manner described as torsion, while those of Patients C and D (flat ridge) deformed in compression.

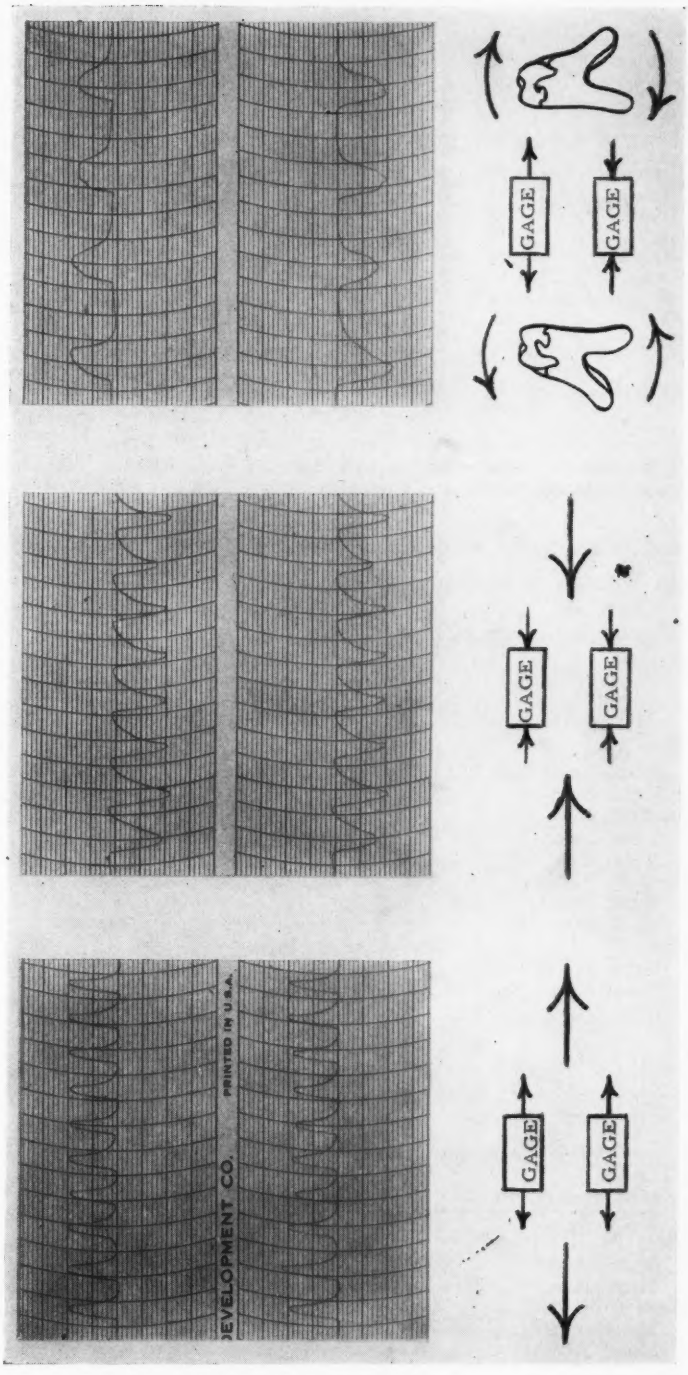


Fig. 3.—Schematic illustrations and recordings of the three types of deformation studied. *A*, Extension; *B*, compression; *C*, torsion.

TABLE I. DEFORMATION OF DENTURE BASES

PATIENT	RIDGE FORM	DENTURE BASE	COMPRESSION DURING MASTICATION (MM.)	EXTENSION DURING DEGLUTITION	TORSION DURING MASTICATION*
A	High	Plastic		0.13	0.36
A	High	Insert		0.05	0.10
A	High	Metal		0.06	0.10
B	High	Plastic		0.17	0.13
B	High	Insert		0.04	0.06
B	High	Metal		0.08	0.06
C	Flat	Plastic	0.13	0.02	
C	Flat	Insert	0.07	0.02	
C	Flat	Metal	0.06	0.02	
D	Flat	Plastic	0.13	0.06	
D	Flat	Insert	0.04	0.05	
D	Flat	Metal	0.05	0.04	

*Values given for torsional deformation are an algebraic summation as contrasted to simple linear measurements for compression and extension.

The percentage reduction in deformation during mastication, as compared to the plastic base denture, is shown in Table II.

TABLE II

	PERCENTAGE
Patient A	
Metal Insert	72
Metal Base	72
Patient B	
Metal Insert	54
Metal Base	54
Patient C	
Metal Insert	46
Metal Base	54
Patient D	
Metal Insert	69
Metal Base	61

TABLE III

	PERCENTAGE
Patient A	
Metal Insert	62
Metal Base	54
Patient B	
Metal Insert	76
Metal Base	53
Patient C	
Metal Insert	0
Metal Base	0
Patient D	
Metal Insert	17
Metal Base	33

DEGLUTITION

Extension of the denture bases of all four patients occurred during deglutition.

The reduction percentage in deformation during deglutition, as compared to the plastic base denture, is shown in Table III.

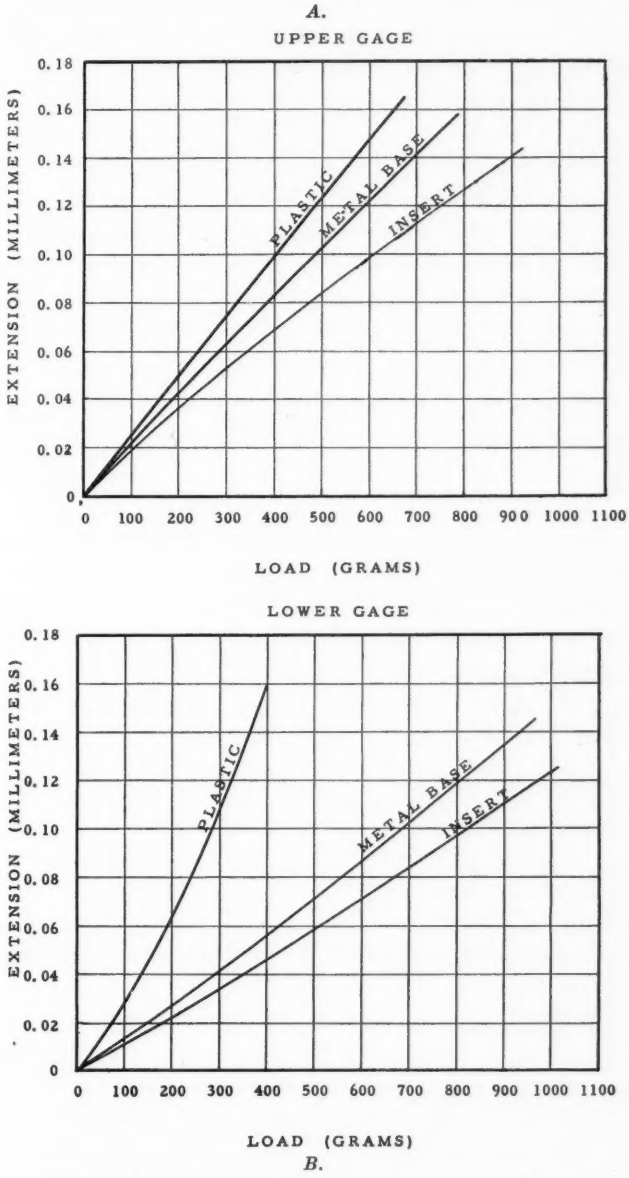


Fig. 4.—*A* and *B*, Extension of plastic, insert, and metal dentures under mechanical load.

During deglutition, the dentures of patients C and D (flat ridge) exhibit less deformation and less stiffening effect of the metal insert and metal base than was

observed for the dentures of patients A and B (high ridge). This is apparently due to the ability of the plastic in bulk to resist the force of the tongue during the act of swallowing.

As a check on the clinical data, the dentures were loaded in extension with various weights. For the high ridge denture, a 60 per cent decrease in the amount of extension was observed with the metal base denture as compared to the plastic base denture when it was subjected to the same load. Within the range of movement encountered clinically, the flat ridge denture showed no significant difference between the deformation in the plastic base and the metal base when the same load was applied.

The relationship between extension and load is shown in Fig. 4,*A* and *B*. A comparison of the curves for the occlusal portion of the base (Fig. 4,*A*) with those for the tissue portion (Fig. 4,*B*) shows that the metal base and insert have more stiffening effect in the tissue portion of the denture. More resistance to deformation, in this instance, was obtained with the insert than with the metal base.

SUMMARY

The data obtained indicates the following: (1) During mastication, (a) plastic base dentures exhibit greater deformation than metal base dentures or dentures with metal inserts, (b) the high ridge dentures exhibit torsional deformation, (c) the flat ridge dentures exhibit compression (or inward movement). (2) During deglutition, (a) the high ridge dentures exhibit extension (or spreading apart), (b) the flat ridge dentures exhibit very little extension.

It is the authors' considered opinion that the data presented indicate that the type of base best suited to resist deformation adequately during function should be selected during the diagnosis and treatment planning for the individual patient. It is thought that the ability of the base to resist deformation is an important factor in adequate stress distribution to the supporting structures.

Acknowledgement is extended to Mr. Charles J. Tracy, Western Representative of General Refineries, for his technical assistance. The metal used in this investigation was Royal Cast, a product of General Refineries, Inc.

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School of Dentistry
University of Washington
Seattle, Wash.

PHYSICAL PROPERTIES OF CORRECTIVE IMPRESSION PASTES

K. Asgarzadeh, M.S., and F. A. Peyton, D.Sc.

School of Dentistry, University of Michigan, Ann Arbor, Mich.

IN SPITE OF THE FACT that little is known about the chemical and physical properties of zinc oxide-eugenol corrective type impression pastes, they are becoming more popular in dentistry. At present, these materials are widely used, in making impressions of the mouth.

It has been realized by those who use these pastes that different products have different characteristics. For example, some are hard to mix, some flow readily, some set fast, while still others possess other properties. They require some kind of physical test, therefore, to compare these different characteristics, and to aid the profession in choosing and using these materials.

So far there is no approved specification for testing these materials, and very little work has been reported by other investigators. In October, 1950, Skinner and his associates[1] published an article which described some of the properties of these materials. Since then, however, most of the manufacturers have improved or modified their products so that the values given in Skinner's article may no longer be applicable. This study was done in order to determine some of the physical properties of products now available.

MATERIALS INVESTIGATED

Seven popular zinc oxide-eugenol pastes were studied. Most of these pastes were purchased on the open market and generally represent two different batches of material. The directions for mixing as outlined by the manufacturer were followed in all cases.

MIXING AND SETTING PROPERTIES

The base and accelerator were squeezed from the tubes on a sheet of paper and mixed with a wide metal spatula. In most cases, half a minute of mixing was sufficient. After the specific paste had been mixed, it was transferred into a copper ring 42 mm. in diameter and 12 mm. in height. The setting time of each paste was tested with a ¼ pound Gilmore needle at fifteen-second intervals. At the beginning, the paste offered no resistance to the Gilmore needle, and, after it was removed from the mix, the paste flowed and filled the impression made by the needle. The time described as initial set was recorded when the paste failed to flow and fill up the impression made by the needle. The final set was designated as the time when the needle did not penetrate into the paste and left only a faint mark on the surface of the paste. From the practical standpoint, these

These studies were aided in part by a contract between the Office of Naval Research, Department of the Navy, and the University of Michigan, (NR 180-360).

Received for publication Sept. 5, 1953; revised by the authors March 3, 1954.

two times are of some importance. In order to obtain a satisfactory result, the paste should be placed in the mouth before the initial set and should not be removed before the final set. It is believed that the shorter the interval between the initial and final set, the better and easier the material is to use.

The setting time of each paste was determined under different conditions, namely, air at 80.0° F. with uncontrolled humidity, water at 80.0° F., water at 99.5° F., and air at 72° F. with 20 per cent humidity. In each of the first three conditions, three different ratios of base to accelerator were chosen to show the effect of proportioning. The one to one is the most common ratio recommended by most manufacturers. Ratios of two parts base to one part accelerator, and one part base to two parts accelerator were chosen to show the effect of two extreme proportionings on setting time. Setting time for water at 80° F. and

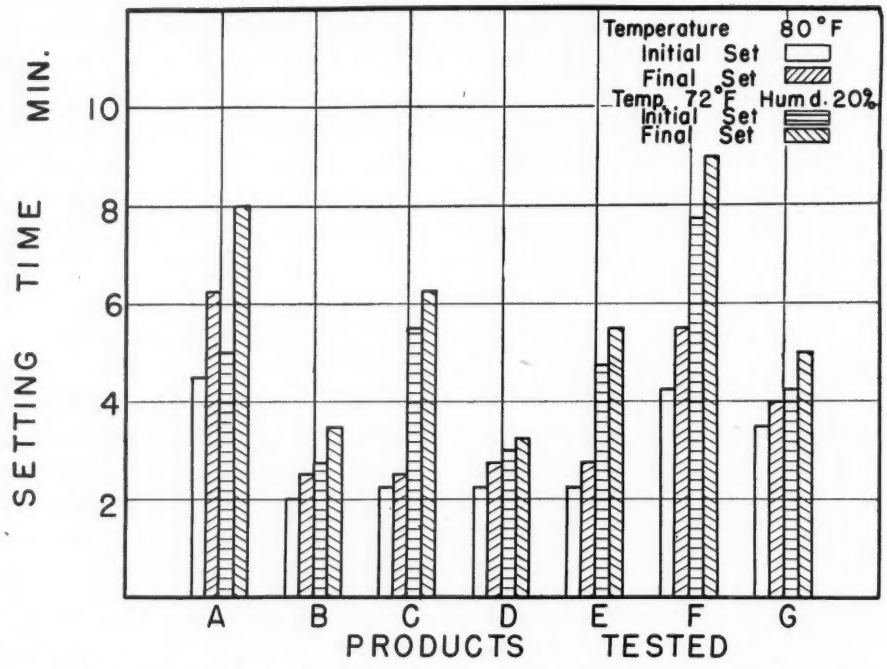

Fig. 1.—Comparison of initial and final set as influenced by temperature and humidity.

99.5° F. was obtained by mixing the paste in air and transferring it into the copper ring, then placing it in water exactly one minute after the start of the mix. The results in Tables I, II, and III show the initial and final sets of different brands with different ratios, in air at 80.0° F. and prevailing atmospheric humidity, in water at 80.0° F. and in water at 99.5° F., respectively. In Table IV is shown the initial and final set as well as flow of different products at 72° F. and 20 per cent humidity when using a one to one ratio. These tables also show the values for flow when tested under the same temperatures and ratio conditions. In Fig. 1 is shown the initial and final set of different pastes in air at 80° F. tested at prevailing atmospheric humidity, and 72° F. with 20 per cent humidity.

TABLE I. SETTING TIME AND FLOW OF IMPRESSION PASTE
(AIR AT 80° F.)

PRODUCT	RATIO 1–1			RATIO 2–1			RATIO 1–2		
	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)
A	4:30	6:15	36	5:15	7:00	38	3:15	4:45	28
B	2:00	2:30	25	3:00	3:30	34	2:45	3:15	29
C	2:15	2:30	38	5:00	5:30	48	2:15	2:30	19
D	2:15	2:45	35	2:15	2:30	35	5:15	6:00	45
E	2:15	2:45	41	2:30	3:00	49	3:15	3:45	37
F	4:15	5:30	48	5:00	6:30	50	3:30	4:15	38
G	3:30	4:00	48	3:45	4:30	48	2:30	3:00	30

Ratio of 2-1 means two parts base and one part accelerator.
In all flow tests 0.5 cm. of paste was used.

TABLE II. SETTING TIME AND FLOW OF IMPRESSION PASTE
(WATER 80° F.)

PRODUCT	RATIO 1–1			RATIO 2–1			RATIO 1–2		
	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)
A	3:45	6:00	34	5:30	8:30	41	2:30	5:00	30
B	2:00	3:00	29	3:00	4:30	32	2:00	3:00	27
C	3:15	3:45	55	5:15	5:45	55	2:30	2:45	45
D	2:00	2:30	28	2:15	2:45	35	7:30	8:45	46
E	2:15	2:45	55	2:15	2:45	50	3:00	3:30	47
F	5:30	6:30	59	8:00	9:00	57	4:30	5:15	50
G	4:30	5:30	55	5:00	6:30	50	3:30	4:15	50

All the samples for setting time are placed in the water after one minute from the start of the mix. The samples for flow test are placed in water after one and one-half minutes from the start of the mix. Time of loading was the same two minutes.

TABLE III. SETTING TIME AND FLOW OF IMPRESSION PASTE
(WATER AT 99.5° F.)

PRODUCT	RATIO 1–1			RATIO 2–1			RATIO 1–2		
	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)	INITIAL SET (MIN.)	FINAL SET (MIN.)	FLOW (MM.)
A	2:45	4:00	34	3:30	5:00	41	2:00	3:00	30
B	1:45	2:15	17	2:00	2:45	30	1:30	2:00	12
C	2:30	2:45	37	3:45	4:00	52	2:15	2:30	37
D	1:45	1:55	17	1:45	1:55	18	2:00	2:45	42
E	1:45	2:00	17	2:00	2:15	17	2:00	2:30	45
F	3:15	3:45	59	4:15	4:45	60	3:00	3:45	53
G	2:15	2:45	55	2:45	3:10	60	1:45	2:00	20

All the samples for setting time are placed in the water after one minute from the start of the mix. The samples for flow test are placed in water after one and one-half minutes from the start of the mix. Time of loading was the same two minutes.

From the results of the setting behavior in air at 80° F., different pastes could be divided into two groups as shown from Table I. Group I includes pastes B, C, D, and E. They are the faster-setting pastes. Initial set in this group is 2:00 to 2:30 minutes with a final set of about 2:30 to 3:00 minutes when the one to one ratio is used. Group II includes the slower-setting type of pastes, such as pastes A, F, and G. The pastes of this group have an initial set of 3:30 to 4:30 minutes and final set of 4:00 to 6:15 minutes.

TABLE IV. SETTING TIME AND FLOW OF IMPRESSION PASTE
(AIR AT 72° F.)

PRODUCT	INITIAL SET SET (MIN.)	FINAL SET SET (MIN.)	HUMIDITY 20 PER CENT FLOW (MM.)
A	5:00	8:00	35
B	2:45	3:30	32
C	5:30	6:15	47
D	3:00	3:15	44
E	4:45	5:30	44
F	7:45	9:00	48
G	4:15	5:00	48

In the water bath, some of the pastes, such as A and F, set faster while others, such as C and G, set more slowly. The setting time of pastes B, D, and E remained approximately the same whether they were left in air or in water of the same temperature. A higher temperature shortens the setting time of all products as is shown by comparing values in the tables.

CONSISTENCY AND FLOW

The test used for measuring consistency and flow was patterned after a similar test devised for the zinc phosphate cements in American Dental Association specification No. 8. For this test, a glass tube with inside diameter of 8.0 mm. was chosen. The tube was marked 10 mm. from one end. In this way, the tube would always deliver a definite volume (0.5 cc.) of mixed paste. The paste was placed between two glass plates and, after two minutes from start of mix, a load of 500 Gm. was placed on the top glass plate. After ten minutes from the start of mix, the load was removed and the diameter of the disk was measured. Two pieces of cellophane were placed between the paste and the two glass plates, to prevent the sticking of the paste to the plates.

Values in Tables I, II, and III show the diameter of the measured disk of the different pastes mixed with different ratios in air at 80° F., in water at 80° F. and in water at 99.5° F., respectively. The samples were placed in water after one and one-half minutes from the start of the mix. Results of flow tests made in air at 80.0° F. with variations in ratio of accelerator to base have been plotted in Fig. 2. In Fig. 3 are plotted the effects of temperature, humidity, and water immersion on a ratio of one part base to one part accelerator. These figures show the consistency to be influenced to some degree by a change in ratio for some products, but, in general, a greater variation in consistency results from a change in

temperature, humidity, and the presence of water on the paste, than from altering the ratio. The flow at 72° F. in air at 20% humidity for a one to one ratio is shown in Table IV.

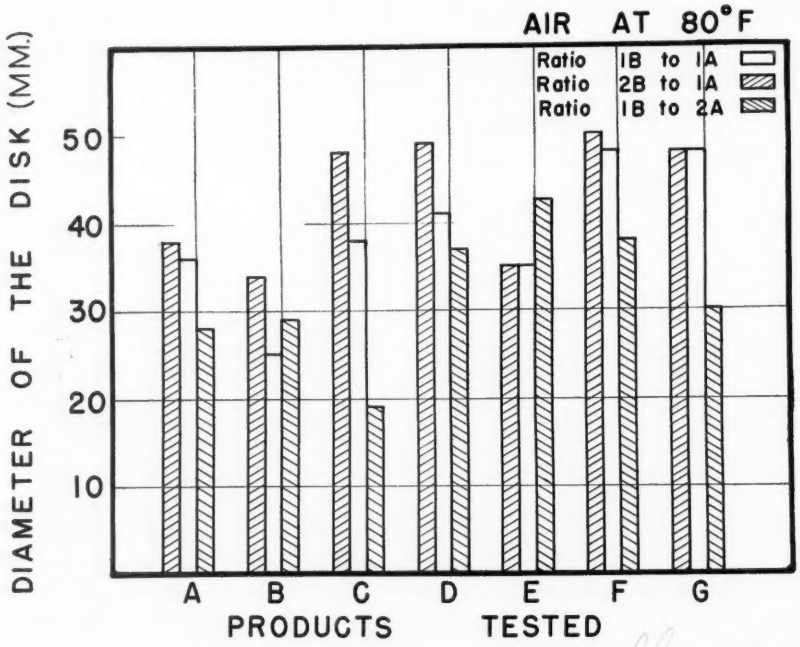

Fig. 2.—Effect of ratio on consistency.

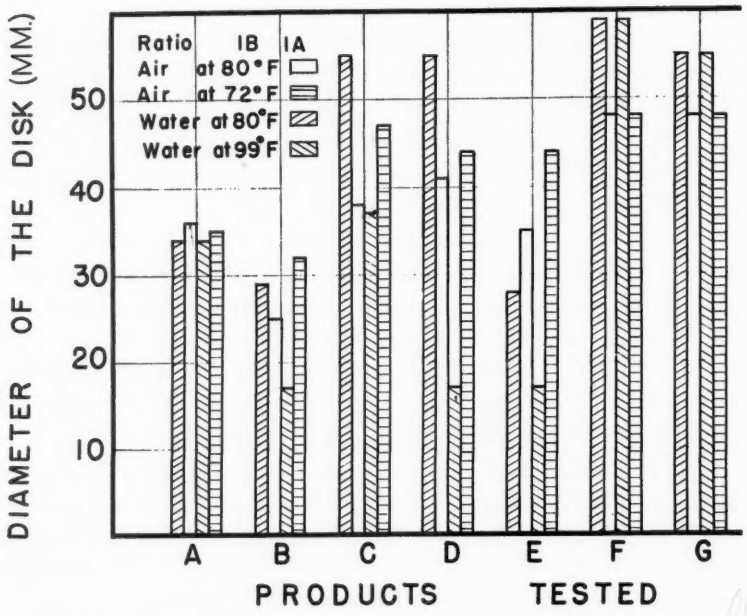

Fig. 3.—Effect of water, temperature, and humidity on consistency.

DETAIL AND SURFACE ROUGHNESS

One of the more important characteristics of a corrective impression paste is the ability to reproduce the impression of the mouth area as accurately as possible. In order to compare this property of different pastes with each other, it was necessary to devise a test method. For this purpose, a piece of thick-walled rubber tubing ¾ inch in diameter and 1½ inch in length was chosen. This rubber tubing has a uniform, fine surface texture, and the purpose was to make an impression of this surface and fill the impression with stone; then compare the stone cast surface with the original rubber surface. Since the impression materials adhere slightly to the rubber, it was necessary to place a coat of suitable separator on the rubber with a camel's hair brush before making an impression. For this

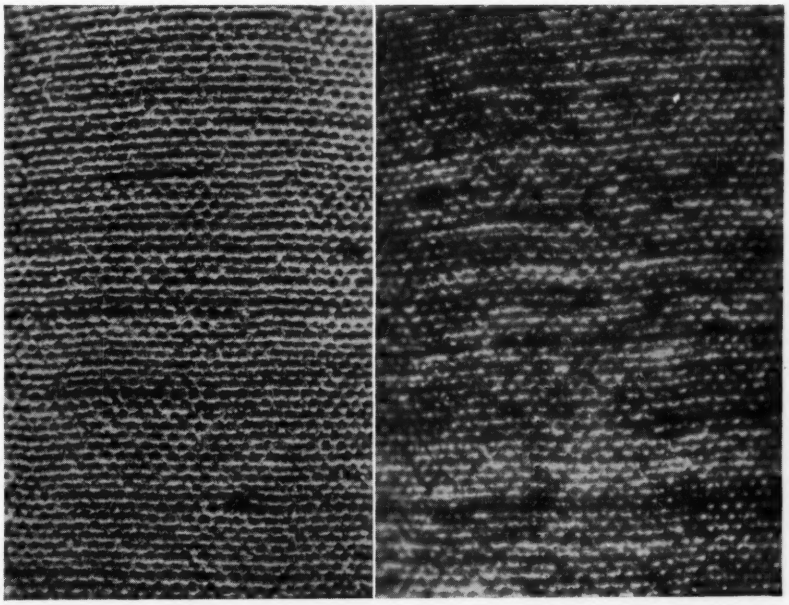

Fig. 4. Fig. 5.

Fig. 4.—Original surface of rubber form, for sample one. (X6).
Fig. 5.—Reproduced surface by impression compound and stone model, for sample one. (X6).

purpose, a solution of a wetting agent or other substance such as microfilm, aerosol, or silicone No. 7 served satisfactorily. Continued use of the same rubber form causes it to lose its fine and sharp detail gradually, for which reason a stone cast poured of later impressions would not be as sharp as earlier ones. Therefore, seven rubber forms were made, one for each paste, and the impression of each form was made by different pastes, and the surface of the stone casts in each case were compared to the rubber surfaces from which the impressions were made.

The comparisons were made by taking magnified pictures of the rubber and stone surfaces. Typical examples of results obtained are shown in Figs. 4 to 7. Figs. 4 and 6 were taken of the rubber surfaces; Figs. 5 and 7 were from the

corresponding stone surfaces. The reproducibility of details was made by comparing Figs. 5 to 4 and 7 to 6, each of which represents good results. The reproducibiilty of the texture of the rubber by the stone was carefully compared. From the standpoint of reproducibility of detail, the pastes may be divided into groups for comparison as, excellent, good, fair, or poor.

At the same time, two other important characteristics of the impression paste materials were studied, namely, surface roughness, and adhesion of the paste to the stone cast. Under a magnifying glass the relative surface roughness of the stone casts was compared with each other. In general, most of them had a relatively smooth surface. Some of the pastes do not show any tendency to adhere to the stone cast, but others, such as paste A, leave a film of paste on the stone cast. Values in Table V show the results of detail, surface roughness of cast, and adhesion of the paste to the cast.

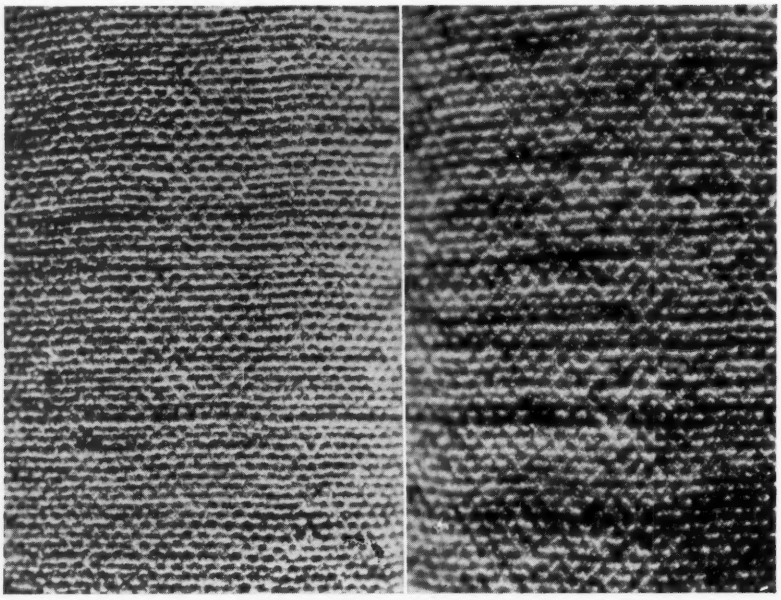

Fig. 6. Fig. 7.

Fig. 6.—Original surface of rubber form, for sample two. (X6.)
Fig. 7.—Reproduced surface by impression compound and stone model, for sample two. (X6.)

TABLE V. REPRODUCTION OF DETAILS AND SURFACE OF THE CAST

PRODUCT	DETAIL	SURFACE CONDITION OF THE STONE	ADHESION OF PASTE TO THE STONE
A	Fair	Poor	Yes
B	Fair	Fair	No
C	Fair	Good	No
D	Good	Good	Slight
E	Excellent	Good	No
F	Fair	Good	No
G	Good	Good	No

STIFFNESS AND COMPRESSIVE STRENGTH

When the paste is removed from the mouth, it should be sufficiently hard and rigid to retain its form and resist fracture, but whether or not the rigidity of the paste should be considered as one of the most important characteristics is not established.

For measuring the strength of the paste, several different tests might be employed. The specific test used for this experiment was a stiffness test patterned after the military specification of the Bureau of Medicine and Surgery, No. 51-P-18 (INT) for Dental Impression Paste. The paste after being mixed according to the manufacturer's directions, is placed between two glass plates. The glass plates are pressed so that the paste forms a sheet 1 mm. in thickness. Five minutes after starting the spatulation, the glass plates and paste are placed in an incubator at 37° C. for one hour. After removal from the incubator, the sheet is trimmed to a strip 1 cm. wide by 4 cm. in length. When the specimen is two hours old, the test is completed on the Tinius Olsen Stiffness Tester using the 0.25 inch pound range and 1 inch span. Results of tests are shown in Table VI.

According to this specification, a specimen should not show more than a 5 degree bend and 1 degree set when 10 per cent of the load is applied, and should break at not less than 15 per cent of the load. As seen from Table VI only paste G meets the requirements of this specification, although paste F is very close. The others do not meet this specification and some of them, such as pastes A and B are far from it.

Since the Tinius Olsen Stiffness test is not a common test, an attempt was made to compare the results of the Tinius Olsen Stiffness test with compressive strength of the materials. Specimens for this purpose were made by placing a cylindrical ring on a flat glass plate; and placing the mixed pastes inside of the ring. A metal mold (0.5 inch inside diameter, 1 inch outside diameter, and 0.75 inch high) was placed immediately inside a thin-walled cylinder which was slightly more than one-half filled with the paste. A metal mold used to form the specimen was forced into the material inside the cylinder until the mold came in complete contact with the glass plate thus forcing the paste to fill the mold. Another glass plate was then pressed on top of the mold to remove the excess material. When the material was set, the cylindrical ring was removed from the mold. The mold filled with paste was then put in an incubator at 37° C. for two hours. A film of silicone grease No. 7 was put on the ring, mold, and glass plates before inserting the paste to allow better and easier separation.

The specimens, after being two hours in an incubator, were removed from the mold and loaded continuously with a compression testing machine at a uniform head speed of 0.2 inch per minute until the specimens fractured. The compressive strength of each paste was calculated, and results are given in Table VI together with results from Tinius Olsen Stiffness test.

As is shown in Table VI there is a correlation between the results obtained from the Tinius Olsen Stiffness Tester and the compressive strength test, except for the pastes F and G, and the other pastes followed the same order in compressive

tests as they did with Tinius Olsen Stiffness test. Paste F and G, however, in the Tinius Olsen Stiffness test both resisted to 16 per cent of the load, while compressive strength of Paste F was 979 pounds per inch^2 and Paste G had a compressive strength of 901 pounds per inch.^{2}

Compressive strength of different pastes as well as stiffness tests were carried out two hours after the final set of the material. An attempt was made to determine if the time interval between the start of the mix and the test is of importance. Therefore, compressive strength of pastes A, D, E, and G were tested fifteen minutes, thirty minutes, one hour, and two hours, after the final set when stored in air at 80.0° F. In Fig. 8 are plotted the results of the compressive strength of these pastes at different intervals from the final set. This figure shows that the strength varies for different pastes after different time intervals.

TABLE VI. STRENGTH OF DIFFERENT PASTES—TINIUS OLSEN TESTER AND COMPRESSIVE STRENGTH

	TINIUS OLSEN TESTER RANGE; 0.25 INCH POUNDS SPAN; 1 INCH				COMPRESSIVE STRENGTH HEAD SPEED 0.2 INCH PER MINUTE
PRODUCT	BREAKING POINT PER CENT OF LOAD	ANGLE OF BEND AT BREAKING POINT (DEGREES)	ANGLE OF BEND AT 10 PER CENT OF LOAD (DEGREES)	SET BY 10 PER CENT OF LOAD (DEGREES)	COMPRESSIVE POUNDS PER INCH^2
A	4	55	———	———	193
B	8	43	———	———	383
C	13	16.5	11	2	682
D	8	21.5	———	———	591
E	9	13	———	———	616
F	16	14	6	1	979
G	16	10	5	less than 1	901

OTHER PROPERTIES

In conducting these tests, other properties of these pastes were also observed. These properties included stickiness or tackiness before and after set, plasticity before set, and action of alcohol and other solvents in cleaning the instruments. Since these characteristics were based on visual inspection, the evaluation might vary in accordance with the opinion of the observer. Some difference was observed between different products with respect to their stickiness or tackiness before and after set. The plasticity of the mix as observed by the operator agreed generally with the measured flow characteristics of the various pastes. In all pastes it was observed that, initially, the mass was relatively stiff, but became more plastic

during the early stages of mixing. Subsequently the mass increased in stiffness as the setting progressed.

All pastes are soluble to some degree in various organic solvents. Alcohol is a moderate solvent for most products studied, but it is not so effective in all products as other solvents such as carbon tetrachloride, benzene, toluene, the commercial product Solutine, or acrylic monomer used in processing resin restorations. The effectiveness of various solvents differs to a great extent.

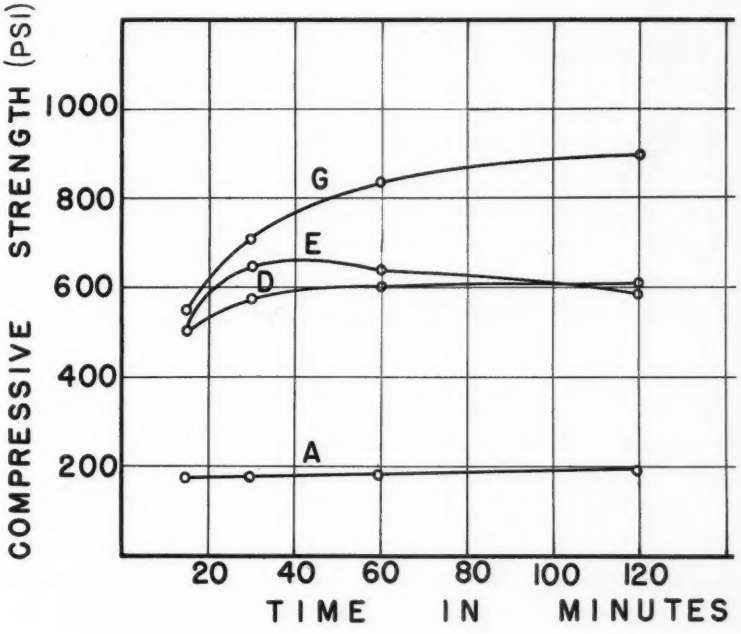

Fig. 8.—Change in compressive strength with time after mixing.

DIMENSIONAL CHANGES

No determination of dimensional changes was made in this study. Since the thin film of corrective paste adheres to the impression compound strongly, there is a good possibility that the actual dimensional change due to the set of the corrective material is almost negligible.

The usual methods of checking dimensional changes are not readily applicable to measurement of thin films of material. If the dimensions of a bar made of an impression paste change during its set, it does not indicate that in the practical instance where the paste is placed against an impression compound, that the same changes will occur. For this reason, the measurement of dimensional change was omitted from this study.

SUGGESTED TESTS FOR A SPECIFICATION

The corrective type of zinc oxide-eugenol impression paste materials are extensively used by the profession although no control of properties exists for these materials through a specification. Accordingly, they are being developed, modified, and used somewhat empirically without a full understanding by the profession of the characteristic physical properties that the product may possess.

This study has revealed that certain physical tests can be made which would serve as a basis for comparison of behavior of the different materials. The properties include the setting time, consistency of the unset mass, reproduction of surface detail, adhesive qualities of the paste for the stone cast, and the strength of the paste.

The setting time can be determined either by the standard Vicat or Gilmore needle method. The time that should elapse before final set is debatable since some operators may prefer a slow reacting material while others would choose a rapid setting one. The time interval between initial and final set appears to be important, however, since the shorter the time interval between initial and final set, the less is the chance of disturbance during the setting process.

The consistency or flow of the unset mass is of some importance, and a test similar to the one described in this study seems desirable. One of the most significant characteristics of these pastes appears to be the ability to reproduce surface details. Some test for this purpose would be desirable. The relative strength of different pastes can be determined by use of a compressive strength test. An excessive strength value seems unnecessary, and pastes which offer a compressive resistance of 450 to 500 pounds per square inch after two hours appear adequate. The rate of load as well as the time interval between final set and start of load application is important. Other general qualities, such as resistance to solvents, adhesive qualities, and surface tackiness might also be incorporated into a specification.

SUMMARY

A study of seven zinc oxide-eugenol impression pastes has been described on the basis of some physical characteristics. These pastes showed measurable differences in properties when one paste was compared with another. The pastes also showed a different response to various manipulative procedures. Comparisons have been made on the basis of mixing consistency, setting time, compressive and bend strength, reproduction of surface detail, and the general qualities of adhesiveness, surface tackiness, and solubility.

It was not the purpose of this study to determine that one product is superior to another, because, at present, it is not known what qualities would constitute a

superior product. Rather it was the purpose to establish the degree of variation that might be expected between different products and as a result of manipulation. It is believed that this study shows the need for a specification for corrective impression pastes, based on appropriate physical or mechanical tests.

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School of Dentistry
University of Michigan
Ann Arbor, Mich.

FUNDAMENTAL PRINCIPLES OF OROFACIAL PROSTHETIC THERAPY IN CONGENITAL CLEFT PALATE

Part II. Prosthetic Treatment*

Ernest Baden, D.D.S., D.F.M.P., L.E.O. (Paris)**

New York, N. Y.

FUNDAMENTAL REQUIREMENTS FOR THE SUCCESSFUL CONSTRUCTION OF OBTURATORS AND SPEECH AIDS

FUNCTION OF THE APPLIANCE

THE PURPOSE of a speech appliance for a congenital cleft palate is to regulate the air column in the oral cavity, restore the missing soft palate (posterior speech zone), close off the rhinopharynx during speech and deglutition, restore the dental arch and the palatal vault for proper articulation, allow normal swallowing (no foods or liquids should penetrate into the nasal cavity), and restore the proper occlusion and the vertical dimension with artificial teeth. It should also restore normal facial harmony.

The anterior incisal occlusal plane should be corrected. The missing teeth should be replaced and the upper lip should be properly supported. The correct vertical dimension and centric relationship must be established.

STRUCTURAL ANALYSIS

The obturator speech aid appliance has three sections (Fig. 1): 1. The hard palate section (*A*). 2. The velar section (*B*). 3. The pharyngeal section (*C*).

THE HARD PALATE SECTION

This section is generally described as the denture base carrying all the units necessary for satisfactory function. It includes: (a) The stabilization and retention framework which consists of the various attachments that retain and stabilize the appliance, such as clasps, precision attachments, indirect retainers, etc. The attachments neutralize the dislodging forces which are very strong because of the long posterior lever arm of the speech aid. (b) The velar extension. At the posterior border of the palatal section is the connector for the velar section. It may be cast in gold, Vitallium, or made in wrought wire. Acrylic connectors are also used. (c) The artificial teeth which are required when teeth are missing

Received for publication Jan. 10, 1953.

*Part I. Diagnosis and Treatment Planning appears in the issue of J. Pros. Dent. 4:420-433, 1954.

**From the Division of Maxillo-Facial Prosthesis, Department of Dental and Oral Surgery, The Mount Sinai Hospital.

or have to be extracted for functional or cosmetic reasons (Fig. 2). (d) The obturator section. When an anterior alveolar or hard palate cleft is present, an obturator bulb in acrylic is processed to the denture base to close off those defects. (e) The supporting plumper for the upper lip. In postsurgical cases where a retruded upper lip is present, a lip plumper or support is constructed which will restore the normal contour of the lip. Acrylic is usually the best material for this purpose.

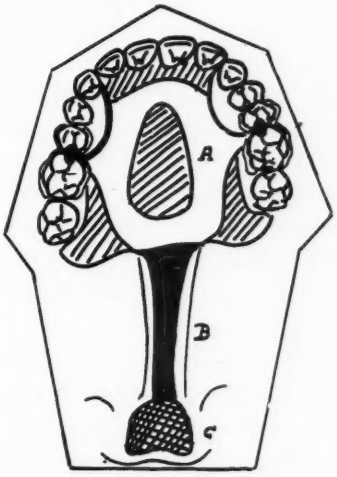


Fig. 1.—The different sections of a cleft palate obturator speech appliance. *A*, The hard palate section, *B*, the velar section, *C*, the pharyngeal section.

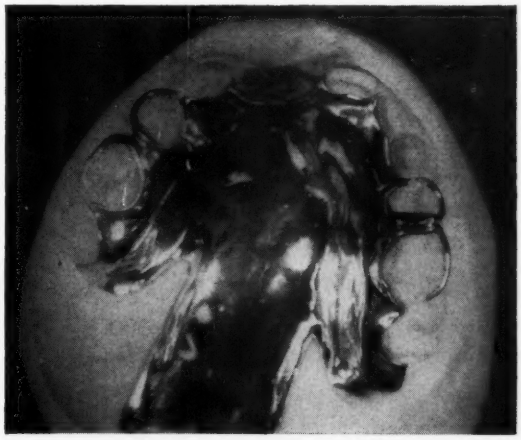


Fig. 2.—Metallic framework for an obturator speech appliance, showing the hard palate and velar section with clasps and saddle for replacement of the upper right central and lateral incisors.

The selection of the type of denture base must be made with care. Three general types of bases are available: (1) the tooth-borne base, (2) the tooth-tissue-borne base, and (3) the tissue-borne base. Depending on the condition of

the teeth and their supporting structures and the examination of the denture-bearing area, the best-suited type is selected. When all the maxillary teeth are present in relatively good alignment and have excellent bone support, a skeletal cast gold or Vitallium framework may be used to advantage. In the average cleft, a skeletal framework is not practical. Often secondary defects of the hard palate are observed and full coverage of this area is highly desirable. If teeth are missing and there is the slightest indication of periodontal involvement of the abutment teeth, we feel that it is best to take advantage of all the denture-bearing area available to distribute the stresses evenly over the bearing area and the teeth. When only a few teeth remain, the denture base should be exclusively tissue borne. The teeth may be used only as means for secondary retention. In edentulous patients, it is difficult to take advantage of the usual principles of retention of full upper dentures based on negative atmospheric pressure, adhesion, and selective placement of tissues as obtained by a peripheral seal and post dam. Additional secondary retention may be secured by extension of the obturator bulb into the nasal cavity and locking it laterally onto the floor of the nasal cavity. The retention attachments are planned in such a way as to provide anchorage without overloading the abutment teeth.

Splinting of the abutment teeth is good practice and provides for a better distribution of the active and passive dislodging forces. Splinting is best accomplished by the use of the full gold crown which protects the teeth from caries and allows for reshaping of the crown to give better retention for clasps and seats for rests.

The master cast is always carefully surveyed according to several paths of insertion and tilts in order to determine the most advantageous position and location of the clasps or other retaining attachments for maximum stability, stress distribution, and retention. It must always be kept in mind that the speech appliance has a long posterior lever arm which absorbs the forces generated by the contraction of the remaining velar muscles and the posterior constrictor pharyngi during speech and swallowing. The forces thus transmitted to the abutment teeth and to the denture-bearing area are much greater than those of a conventional upper partial denture. Any desirable attachments such as rests and indirect retainers may be provided for if full crowns are used. Auxiliary retention devices such as the Schuiringa tube-lock[1] may be soldered to the crowns for stabilization of the speech aid in children when only the deciduous teeth are used as abutments.

The requirements of the denture base material are: that it be light in weight, simple, and easy to construct and repair, readily adjustable, inexpensive, non-irritating to the soft tissues, rigid, and sturdy; it must also have good thermal conduction, good cosmetic appearance, strength in thin sections, and precision fit in complex designs. Present-day denture materials are satisfactory in most respects.

In addition to technical and biologic considerations, certain fundamental speech requirements must be met. Resonance and articulation are influenced by the position of the anterior teeth, the height and contour of the palatal vault, the incisal occlusal plane, and the free-way space. The pronunciation of consonants is affected by those factors. McDonald[2] points out that the palatal section should restore the

missing teeth properly, obtain a normal relationship of the maxillary and mandibular incisors, and form a smooth, high-vaulted palate. The chrome alloys may be used in very thin sections which is of advantage for some patients.

In certain patients, the hard palate has collapsed after early surgery, and teeth have erupted in poor alignment. Secondary perforations and other defects also are usually present. Careful planning is necessary for this group of patients. The defects must be first corrected and a satisfactory denture-bearing area created before the construction of an appliance can be attempted. Prosthetic treatment is often the last resort after a surgical failure, and it is essential to ensure the best conditions for the stabilization, the retention, and the function of the speech aid. Corrective oral surgery is often indicated to create a proper denture-bearing area. Operative procedures may involve the upper lip, alveolar sulcus, alveolar ridge, hard and soft palate, and muscle insertions. Harkins[8] advocated redivision of the soft palate for certain patients. When teeth are retained in malposition, they are ground down and covered with gold thimbles. The denture base will cover the teeth and produce a smooth, slightly vaulted lingual surface. The disadvantage of such an appliance is, of course, the reduction of the volume of the oral cavity, which affects the resonance. Acrylic bases are more readily adjusted, and, therefore, easier to handle in complex and mutilated clefts.

THE VELAR SECTION

The velar section is the intermediary section between the denture base and the pharyngeal speech bulb. It must be rigid to give support to the speech bulb. Generally, a metallic or reinforced acrylic extension is best. This section has a physiologic function. It must compensate for the lateral movements of the velopharyngeal muscles and support them during their contraction. Proper muscle trimming is necessary when making the impression for the denture base and velar extension, for the width and vertical position of this section are critical.

The vertical position of the velar section has to be carefully considered. 1. It should be placed in such a relationship with the soft palate so that it does not interfere with normal tongue movements. 2. It should provide a close-to-normal resonance chamber. 3. It should not exert any undue pressure on the velar musculature. The last point should be stressed. Pressure will not only tend to dislodge the appliance and consequently overload the abutment teeth, but also it will result in soft tissue irritation, damage to, and possible atrophy of, the musculature. Failure of the appliance results frequently from overplacing of the soft tissues during impression making. A hydrocolloid impression material is best for the impression of this region. The velar section is placed as high as possible so that it does not interefere with any other structure.

THE PHARYNGEAL SECTION OR SPEECH BULB

The pharyngeal section must fulfill certain basic requirements: 1. It must be functional by closing off the nasal cavity from the mouth and pharynx during speech and deglutition. This is achieved by the correct size, shape, and location

of the bulb. The pharyngeal section is best located at the point of maximum contraction of the posterior constrictor muscles and remaining velar muscles (Fig. 3). At rest position, the posterior surface of the bulb should be slightly anterior to Passavant's pad. 2. It must be biologic, well-tolerated by the tissues, nonirritating, and easy to clean and sterilize if necessary. It should not exert any pressure on the posterior pharyngeal wall. It must be made of a permanent material which is not subject to any chemical reactions in vital fluids. 3. It must be mechanically sound. The bulb must be easy to adjust and to construct. It must be transparent to enable the dentist and the speech therapist to observe the tissues for possible interference during rest and function. It should be dimensionally stable.

Fig. 3.—Pharyngeal section. Concavity of the speech bulb for the contracting forward bulge of the superior constrictor pharyngi muscles at Passavant's pad.

The anatomic landmark generally used for the posterior extension of the speech bulb during function is the region of Passavant's pad,[4] which corresponds to about the position of the anterior tubercle of the atlas. The contraction of the posterior constrictor pharyngi muscles is greatest in an anterior direction at this point. The posterior surface of the bulb should be in contact with the posterior constrictors during their contraction. The vertical position of the pharyngeal section is important. If the inferior posterior border of the bulb is too low, the space between the tongue and the palate is decreased and the pronunciation of vowels may be impaired.[2] A position that is too high should also be avoided. The best method for determining the correct position of the speech bulb in all directions is by precise and progressive muscle trimming. This technique will outline the area of maximum contraction of the velopharyngeal sphincter. Muscle trimming is performed with a soft impression material, such as low-fusing wax, gutta-percha, low-fusing impression compound, special impression resins, alginate mixed with cornmeal, etc. (Fig. 4). The material must stay plastic for some time and be soft enough to register accurately the musculature in function. It should also have enough body so that it will not run. The patient is instructed to perform certain physiologic movements that activate all the velopharyngeal muscles, such as turning the head forcibly

from the right to the left, bending the head down to the chest and all the way back, swallowing repeatedly, opening and closing the mouth all the way, speaking, whistling, and laughing.

Where a satisfactory result cannot be obtained with the patient in one appointment, the impression material may be left in the mouth if it is securely luted to the velar extension of the denture. The patient may be instructed to continue the exercises for one week in order to complete the muscle trimming. Speech therapy may also be instituted with the impression material in place. When the exact location, dimension, and shape of the bulb have been functionally determined, the impression is chilled, and removed from the mouth; the bulb is duplicated in a permanent material. A solid or hollow clear acrylic bulb may be constructed. In the average cleft, a solid, clear acrylic pharyngeal section is satisfactory.

Fig. 4.—Latex obturator, feeding aid for the newborn infant. (Courtesy of Dr. Alfred Sheppard.)

Cephalometric profile roentgenograms, with the appliance in place at rest and during function, help to determine the correct posterior extension of the bulb (Fig. 5). A radiopaque material is painted on the posterior pharyngeal surface of the bulb, or tin foil is burnished and glued on to this surface. Then the roentgenograms are made. The relationship of the bulb to the posterior constrictor muscles may be determined quite accurately in that way.

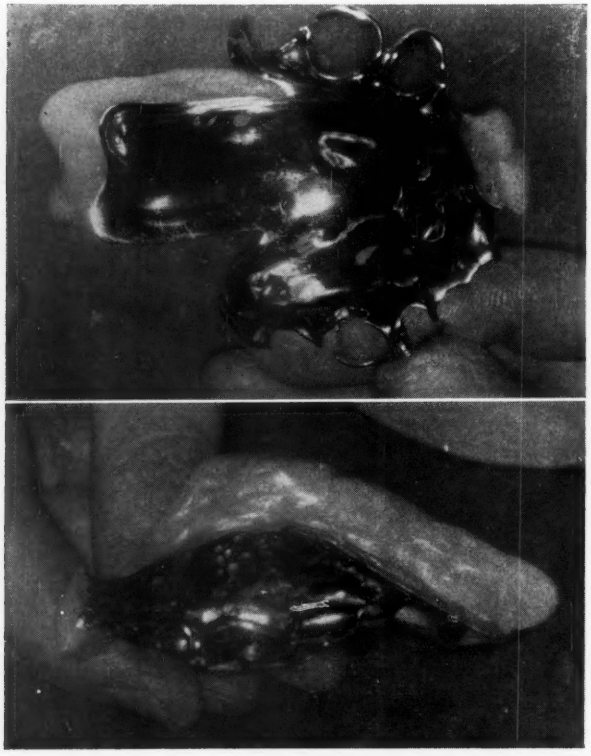
Overextension and underextension must be determined early to prevent atrophy of the muscles or air leaks. Clinically, the pharyngeal section may require many adjustments. Pressure spots develop, and the acrylic must be carefully relieved. Adjustments become more frequent when speech therapy is started. These are necessary in order to compensate for the hypertrophy of the posterior constrictors which is stimulated by the phonetic exercises. Some interference with speech may also occur at first.

According to McDonald,[2] the speech therapist can advise the dentist when adjustments are required after speech therapy has been instituted for some time. Some signs indicative of interference and required reduction of the size of the bulb are: (1) feeling of fullness and soreness of the throat, (2) difficulty in

breathing, (3) denasality (absence of resonance, particularly when pronouncing the nasal consonants m, n, and ng). The dentist, by clinical examination of the mucosa, will be able to detect sore spots, irritation, and gross interference during rest and function.

Requirements for the proper construction of a speech aid are manifold, and require a good grasp of the fundamental principles of anatomy, physiology, and surgical pathology. Prosthetic therapy has offered many ingenious appliances for the management of congenital cleft palate. Each has its respective place in the treatment of the cleft palate patient.

A.



B.

Fig. 5.—*A* and *B*, Speech aid for the adult patient in chrome cobalt alloy with artificial teeth, velar, and pharyngeal sections for a Class II cleft.

CLASSIFICATION OF PROSTHETIC APPLIANCES USED IN CONGENITAL CLEFT PALATE THERAPY ACCORDING TO THEIR INDICATIONS

Prosthetic treatment of congenital cleft palate patients may be divided into presurgical (Fig. 4), surgical, intermediate, and postsurgical prosthesis.

PRESURGICAL PROSTHESIS

Presurgical prosthesis encompasses the construction of feeding aids, latex obturators, and acrylic obturators, which may be used in the complex clefts where

adequate feeding is a problem and where the cleft palate nipples available are not satisfactory. These appliances have to be renewed periodically because of the rapid growth of the palate in early childhood. Speech aids constructed for very young children are considered to be in this group.

SURGICAL PROSTHESIS

Surgical prosthesis includes all the splints, stents, and temporary obturators used for the support and protection of the palatal flaps and the suture line and for the shaping up of the palatal vault according to the designs of Axhausen,[5] Schmuziger,[6] and Gross.[7] Scaffolding splints for the correction of secondary deformities, such as ridge extension procedures of the upper alveolar sulcus, correction of lip contour, freeing of the upper labial frenum, and section of scar tissue adhesions holding the upper lip down are very often indicated. Kazanjian[8] has described those appliances in detail and has given their indications. They may have fixed retaining frameworks or removable partial denture stents. The plastic surgeon and the prosthodontist will plan the construction of the appliance on the cast.

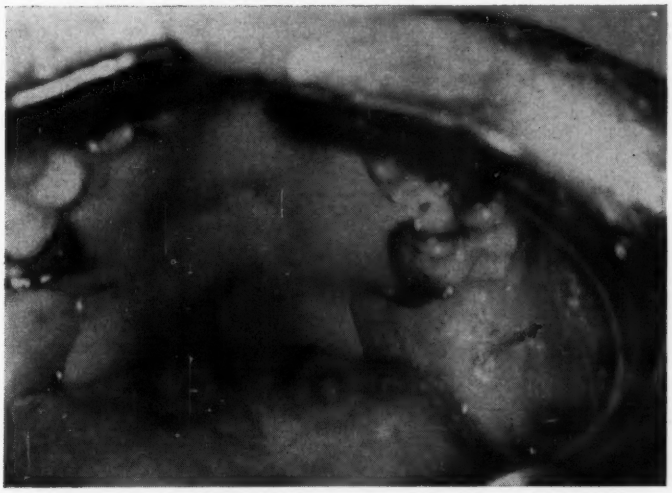


Fig. 6.—Intermediate speech appliance for a cleft of the soft and hard palate in acrylic with wrought wire clasps.

INTERMEDIATE AND POSTSURGICAL PROSTHESIS

Intermediate and postsurgical prosthesis requires the construction of obturators and/or speech aids. Among the former, Pickerill's obturator for the hard palate cleft,[9] Schalit's meatus obturator,[10] and Gillies and Fry's appliances are best known.

Speech aids are complex in their design and require a more detailed classification. The fundamental requirements for their construction have to be analyzed. Only the different types of appliances used will be mentioned.

The Artificial Velum.—This is essentially a soft palate obturator acting as a speech aid. No denture base is constructed, the soft palate retains the appliance. Case[11] described this speech aid in detail.

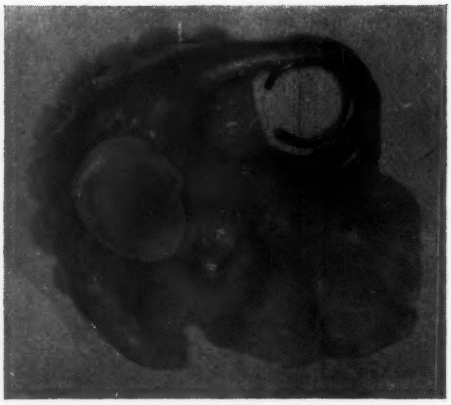


Fig. 7.

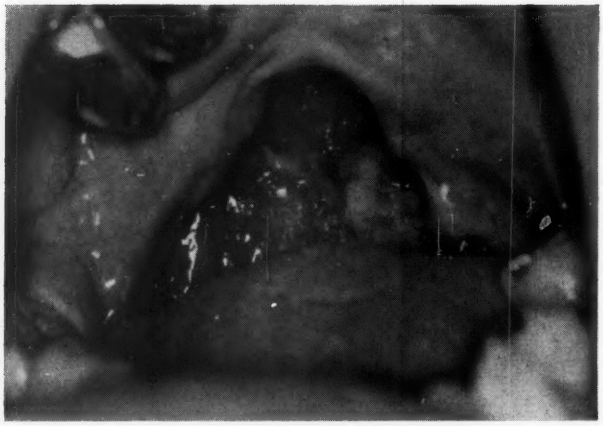


Fig. 8.

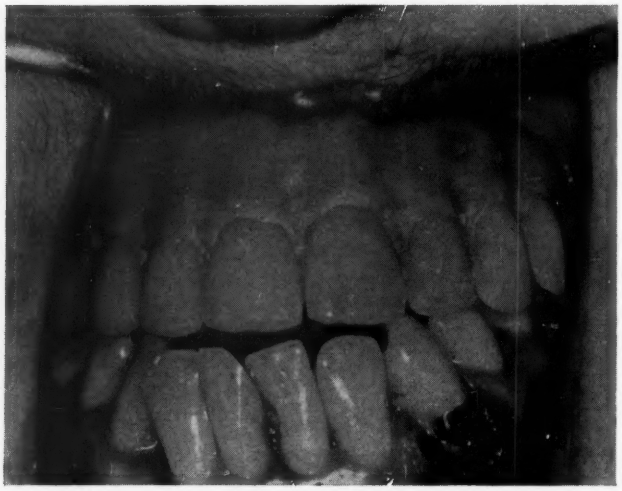


Fig. 9.

Figs. 7, 8, and 9.—Postsurgical failure treated with a prosthetic speech appliance; all-acrylic obturator with speech bulb, retained by wrought wire clasp and indirect acrylic retainer, replacing the anterior teeth and incorporating a lip plumper.

The Movable Velum.—The pharyngeal section of this appliance is movable around a pinlock hinge, a spring, or other movable joint. The Kingsley type speech aid is still used with some modifications for certain patients. This speech aid is not universally used because it is a complex and delicate prosthetic appliance. It is difficult to repair and to adjust and expensive to construct. The movements of the artificial velum are not physiologic as it was first believed. The pressure of the spring causes muscle atrophy after prolonged use of the prosthesis. This is due to the fact that the remaining wings of the velar musculature have to support the artificial velum; the spring exerts a continuous pressure on the soft tissues.

The Fixed, Rigid Speech Aid.—Many modifications of the basic design have been described. The Suersen appliance[12] is truly the typical fundamental design of the functional rigid speech aid. The basic design has, of course, been altered and adapted to modern trends in congenital cleft palate therapy. Fitz-Gibbon, for instance, constructed an all metal obturator speech appliance which has a wide range of indications and which may be applied for the most difficult patients. Wright's all acrylic appliance is truly the first constructive answer to the social and professional problems which arise when great numbers of patients have to be treated in specialized cleft palate centers and hospitals, where efficiency, speed, and the highest standards of professional care have to be met. This appliance is adaptable to many patients, easy to construct, reasonable in cost, and functional. All temporary obturator speech appliances may be constructed according to Wright's technique.

Fig. 10.—Diagram of the respective positions of the pharyngeal sections with: *I*, the fixed rigid functional speech appliance; *II*, the movable velum speech aid; *III*, the Schalit meatus obturator; *a*, Passavant's pad contracted on the posterior pharyngeal wall, *b*, the relaxed contour.

Innumerable modifications of the basic design have since been made by Harkins, Olinger, Cooper, Lifton, Schuiringa, Psaume, and others. Any appliance will be satisfactory if the fundamental anatomic, physiologic, and technical requirements

are met. It is the accurate diagnosis and well-prepared treatment plan which actually ensure successful therapy. It is not meant that the construction itself is to be neglected. It follows that the prosthetic technique used to produce the appliance must be precise and exacting.

SUMMARY

The fundamental principles of anatomy, physiology, pathology, clinical diagnosis, and treatment planning as they apply to the scientific approach to the congenital cleft palate problem have been discussed. (Fig. 10).

Essentials of denture design as they apply to orofacial prosthesis have been described and the indications of prosthetic treatment were analyzed.

A detailed description of the construction of the rigid speech appliance used in congenital cleft palate therapy was given. Appliances used in the different treatment stages of congenital cleft palate were discussed.

CONCLUSION

Rehabilitation of the congenital cleft palate patient may be successful only if a warm, sympathetic approach is made toward the patient by a team of specialists familiar with the possibilities and limitations of medical, surgical, phonetic, psychologic, dental, and prosthetic therapy. Often the prosthodontist may face the challenging problem of the postoperative failure, where all his ingenuity, knowledge, and skill will be required to obtain a satisfactory result. He will be asked to participate actively in all the phases of congenital cleft palate therapy.

This work is always challenging and stimulating to the intellect and common sense, as well as rewarding in many ways.

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139 W. 82ND ST.
NEW YORK, N.Y.

News and Notes

ANNOUNCEMENTS

The American Denture Society will hold its twenty-sixth annual meeting Nov. 5 and 6, 1954, at the di Lido Hotel, Miami Beach, Fla. Hotel reservations must be made through the Housing Bureau of the American Dental Association.

The American Academy of Restorative Dentistry will meet Feb. 5 and 6, 1955, at the Conrad Hilton Hotel, Chicago, Ill.

The Teaching Division of the Dental Department of Beth Israel Hospital announces a conference and seminar in Periodontology Sept. 13 to 24, 1954, under the direction of Dr. Henry M. Goldman. For further information write to Marcia Lane, Coordinator of Education Programs, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

The Greater New York Dental Meeting will be held Dec. 6 through 10, 1954, at the Hotel Statler.